

Do deaf children with Autism Spectrum Disorder show
deficits in the comprehension and production of emotional
and linguistic facial expressions in British Sign Language?

Tanya Denmark

University College London

A thesis submitted for the degree of Doctor of Philosophy

April 2011

Statement of originality

I, Tanya Denmark confirm that the work presented in this thesis is my own. Where information has been derived from other sources, I confirm that this has been indicated in the thesis.

T Denmark

Acknowledgements

I have thoroughly enjoyed working on this PhD thesis. I would like to thank John Swettenham, Joanna Atkinson and Ruth Campbell for their excellent supervision, guidance and support throughout this research period. Additional thanks go to Adam Schembri and Bencie Woll who gave me additional academic support regarding coding of sign language, sign language linguistics and advice regarding atypical deaf sign language users. David Vinson and Paul Bassett offered excellent statistical advice which helped me through numerous quandaries. Michael Coleman was also instrumental in helping me to program some of the comprehension tasks used in the thesis. I am also grateful to all of the staff at the deaf child young person family service for their academic and clinical advice and commitment to helping me recruit for this study, particular thanks go to Constanza Moreno and Joanna Hoskin. I am extremely grateful to all the children and young adults who took part in this research and the many schools who helped this happen (Hamilton Lodge School, James Wolfe School, Derby School for the deaf, Royal Margate School for the deaf, Westgate College, Frank Barnes School, Longwill School, Exeter School for the deaf, Signpost residential services, Thomas Tallis School and Elmfield School for the deaf). I am also thankful to all the teachers and speech and language therapists who supported these visits. My particular thanks go to all pupils and staff at Hamilton Lodge School, especially to Hilary Dumbrill for being my saviour and helping me organise my testing sessions.

I would like to thank the staff at DCAL, the department of developmental science, University College London (UCL) and Laboratory for Language and Cognitive Neuroscience (LLCN, San Diego State University) for their knowledge sharing and advice

and giving me opportunities to discuss and present my work and Judy Reilly for offering input and methodological advice on some of the earlier experiments (in chapter 4 and 5). Anna Remington, Jordan Fenlon, Zed Sevcikova, Donna Lewin and the other fellow PhD students at DCAL and developmental science must be acknowledged for constant knowledge sharing, inspiration and office support. I would also like to thank other colleagues: Robert Adam, Kate Rowley and Mischa Cooke for acting as adult sign language models and Ramas Rentelis for assisting with second-coding of the data. Tyron Woolfe, Pam Morgan, Jordan Fenlon, Clark and Carolyn Denmark for modeling photographic illustrations. I would also like to thank my parents who have been excellent role models to personally support and encourage me along the way, Tyron Woolfe for helping me discover an interest in research and supporting my move to London and early career as a researcher, as well as other family members and friends who have offered their interest and encouragement along the way. Further thanks go to my former housemate Emma for numerous cups of tea and watching of practice presentations and Chris for constant moral support and encouragement throughout the final stages of writing and submitting, I wouldn't have done it without you all.

The work was generously supported by the ESRC and University College London.

Abstract

Normally hearing children with ASD are often reported to have a lack of interest in others, particularly when looking at faces, as a result of this they manifest difficulties understanding and using facial expressions compared to typically developing controls. Deaf children often show advantages with the processing of the face, as they need to look to the face more to communicate, due to the presence of linguistic facial expressions in British Sign Language (BSL). It is unknown how deaf individuals with ASD will fare when processing faces. This is the first study to look at how deaf children with ASD compare to typically developing deaf controls on a face processing measure and a number of comprehension and production measures looking at affective and linguistic facial actions in BSL.

Surprisingly the deaf ASD group showed no general face processing impairment or difficulty attending to the face for the purpose of communication, they did not show characteristics usually associated with hearing individuals with ASD. This suggests the extra experience gained from attending to faces may reduce face processing impairments in deaf individuals with ASD. More research is needed to warrant this conclusion. The deaf ASD group did demonstrate specific impairments with the comprehension and production of some affective facial expressions in BSL. Linguistic facial expressions were largely preserved, with the exception of adverbials. The impairments that emerged in the deaf ASD group were most pronounced when production or comprehension of the face required attributions about the mental states of others. These results suggest that deaf individuals with ASD are not impaired with face processing, rather they have a highly specific and subtle pattern of impairments with using the face in sign language.

Contents

Acknowledgements	3
Abstract.....	5
List Of Tables	17
List Of Figures.....	18
Chapter 1: Do deaf children with Autism Spectrum Disorder (ASD) show deficits in the comprehension and production of emotional and linguistic facial expressions in British Sign Language?.....	25
Literature Review.....	25
Definitions, prevalence and co-occurrence: ASD and deafness	25
ASD	25
Diagnosing ASD in deaf children	26
Deafness.....	28
Co-morbidity of ASD and deafness.....	29
Problems with diagnoses of deafness and ASD.....	31
Face processing impairment in ASD	32
Theory of Mind	37
Is there a relationship between face processing impairments and ToM?.....	39
Characteristics of Sign Language	41
Acquisition of Sign Language	46
Sign Language and ASD.....	47
Teaching Sign Language to hearing individuals with ASD.....	49

Recent research on deafness and ASD.....	53
Studies comparing deaf and hearing children with ASD.....	53
Studies comparing deaf ASD with deaf typically developing controls	55
Studies on Sign Language production in deaf individuals with ASD.....	56
Filling in the gaps: How does this thesis follow on from existing research?.....	58
Chapter 2: Participant recruitment and characteristics	59
Recruitment.....	59
Ethical approval	61
Participant characteristics: ASD and control groups	62
Participant matching	63
Chronological age.....	63
Non-verbal ability.....	63
Language ability	64
BSL Comprehension.....	64
BSL Narrative Skills Test: production ability.....	66
Procedure	68
Chapter 3: Are deaf individuals with ASD impaired on the Benton Facial Recognition Test.....	70
Introduction.....	70
Face processing and ASD	73
Methodological issues.....	74
Deafness and face processing	76

Experiment 1	80
Hypothesis	80
Methodology	81
Participants.....	81
Materials	82
Benton Facial Recognition Test.....	82
Procedure	82
Results.....	83
Discussion.....	84
Chapter 4: Are deaf individuals with ASD able to recognise affective facial expressions in BSL in masked and unmasked conditions?	88
Introduction.....	88
ASD and recognition of affective facial expressions.....	89
Recognition of subcategories of emotion.....	89
Emotions in Sign Language	91
Facial masking in deafness and ASD.....	91
Current study.....	93
Experiment 2.....	94
Hypotheses.....	94
Methodology	94
Participants.....	94
Test development.....	94

Materials	96
Procedure	96
Results.....	97
Complexity.....	104
Discussion.....	105
Chapter 5: An analysis of emotional facial expression production in deaf individuals with ASD using the BSL Narrative Skills Test	112
Introduction.....	112
Facial expression production methodology	114
BSL Narrative Skills Test.....	115
Experiment 3.....	116
Hypothesis	116
Methodology	117
Participants.....	117
Materials	117
Procedure	117
Coding system.....	118
Analysis	120
Results.....	123
BSL proficiency: additional measures from the BSLNST.....	127
Narrative content.....	127
Narrative structure	128

BSL grammar.....	128
Discussion.....	133
Chapter 6: How do deaf individuals with ASD produce linguistic and affective facial expressions in a sentence repetition task?.....	141
Introduction.....	141
Linguistic facial expressions.....	141
Neural localisation	142
Hearing people with ASD.....	144
Affective facial expressions- methodological issues	145
Sign Language sentence repetition	146
ASD and imitation	149
Experiment 4.....	150
Hypothesis	151
Methodology	151
Participants.....	151
Materials	151
Procedure	153
Coding system.....	154
Results.....	155
Linguistic facial expressions.....	157
Affective facial expressions.....	158
Discussion.....	161

Chapter 7: How do deaf individuals with ASD comprehend and produce facial expressions of negation in BSL?	166
Introduction.....	166
Acquisition of negation.....	171
The function of negation.....	174
Syntactic function.....	174
Intonational function.....	175
Experiment 5a: The test of BSL negation comprehension in deaf individuals with ASD and typically developing deaf controls	179
Hypothesis	179
Methodology	179
Participants.....	179
Materials	180
Procedure	183
Results.....	183
Discussion	186
Experiment 5b: The test of BSL negation comprehension-masked.....	188
Hypothesis:	189
Methodology	190
Participants.....	190
Materials	190
Procedure	193

Results.....	193
Discussion.....	198
Experiment 5c: Negation Production Test.....	200
Hypothesis:	200
Methodology	200
Participants.....	200
Materials	200
Procedure	201
Coding System.....	202
Results.....	203
Discussion.....	209
Overall Discussion.....	211
Chapter 8: How do deaf individuals with ASD categorise and produce question facial expressions in BSL?	213
Introduction.....	213
Acquisition of questions in Sign Language	214
Comprehension of questions in Sign Language.....	216
Question comprehension in ASD.....	217
Experiment 6a: Question categorisation test.....	218
Hypothesis	218
Methodology	219
Participants.....	219

Materials	219
Procedure	221
Results.....	222
Discussion.....	223
Experiment 6b: Question Production Test.....	227
Production of questions in ASD	227
Production of questions in Sign Language	228
Hypothesis	231
Methodology	232
Participants.....	232
Materials	232
Procedure	233
Coding system.....	233
Results.....	235
Discussion	240
Overall Discussion	242
Chapter 9: How do deaf individuals with ASD comprehend and produce adverbial facial expressions in BSL?	244
Introduction.....	244
Unique role of adverbials: adverbials and other NMMs.....	247
Adverbials and affective facial expressions.....	249
Experimental studies of adverbials in Sign Language	251

Acquisition of adverbials in Sign Language	252
Experiment 7a: Adverbial comprehension test	255
Hypothesis	255
Methodology	256
Participants.....	256
Materials	256
Procedure	261
Results.....	261
Discussion.....	264
Experiment 7b: Adverbial Production Test	266
Hypothesis	266
Methodology	266
Participants.....	266
Materials	266
Procedure	267
Coding system.....	267
Results.....	269
Discussion.....	275
Overall Discussion.....	279
Chapter 10: General results, discussion and conclusions.....	282
Accuracy scores	282

Reaction time scores	284
Differences in quality of face actions	285
Discussion and conclusion.....	285
Face processing (experiment 1)	286
Affective facial expressions in Sign Language (experiments 2-4)	287
Linguistic Facial expressions in Sign Language (experiments 4-9)	288
Theoretical explanations	289
Alternative theories of ASD.....	294
Perspective taking.....	294
Mirror Neuron theory.....	295
Methodological strengths.....	296
Methodological weaknesses.....	297
Other tasks	297
Sample size and age range	298
Recruitment and diagnostic uncertainties	299
High function inclusion bias	299
Group level analysis.....	300
Quality of BSL exposure	301
Implications for diagnosis and intervention.....	301
Future research.....	303
Face processing.....	303

ToM.....	304
Detailed investigation of adverbials	304
Extending existing findings to hearing individuals with ASD.....	305
Timing and Scope	306
Conclusions.....	308
Appendix 1: Example emotion recognition scoresheet.....	310
Appendix 2: Binomial tests raw data	311
Appendix 3: Example BSLNST scoresheet.....	314
Appendix 4: List of items and trials for Experiment 5b, (The BSL test of negation comprehension, masked and unmasked trials	315
Appendix 5: Example coding sheet for Experiment 5c, The negation production test.....	318
Appendix 6: List of the questions and commands used in Experiment 6a (not in testing order) (Question categorisation test).....	319
Appendix 7: Video-Clips and pictures used in Experiment 7a (adverbial comprehension test).....	321
References.....	324
Table of abbreviations.....	352

List of tables

Table 2:1: Matching of participant groups in chronological age, BSL ability, non-verbal ability and severity of ASD.....	64
Table 4:1: Example sentences used in experiment 2	94
Table 4:2: Confusion matrix showing correct responses and errors made by the deaf ASD group in face masked condition, (* marks significantly different confusion patterns from chance).....	99
Table 4:3: Confusion matrix showing correct responses and errors for deaf ASD group in unmasked condition (* marks significantly different confusion patterns from chance)	99
Table 4:4 Confusion matrix showing correct responses and errors for deaf controls in face masked condition (* marks significantly different confusion patterns from chance)	100
Table 4:5 Confusion matrix showing correct responses and errors for deaf controls in unmasked condition (* marks significantly different confusion patterns from chance)	100
Table 5:1: Number of affective expressions in the BSLNST	119
Table 5:2: Affective expressions in the BSLNST and their corresponding facial actions... ..	120
Table 5:3: Median facial expression target production for different emotion types for both groups	124
Table 5:4: Number of facial actions per emotion (significant difference between groups marked by *)	133
Table 6:1: Sentences and facial actions in sentence repetition test.....	152
Table 7:1: Significance levels (above chance) per group for each condition.....	197
Table 9:1: Examples of different adverbial types (some ASL, some BSL definitions) with descriptions of facial actions and meanings.....	243
Table 9:2: Target facial actions for each picture.....	268

List of figures

Figure 1:1: NOTHING manual sign and facial NMM for negation	43
Figure 1:2: Facial NMM for yes-no question	44
Figure 1:3: WHAT manual marker and facial NMM for Wh question	44
Figure 1:4: PU mouth pattern which is produced with the sign FINALLY.....	44
Figure 1:5: Manual sign BOY.....	56
Figure 2:1: Mean scores and standard error on the SRS scale for deaf individuals with ASD and deaf controls	61
Figure 2:2 BSLRST grammatical subscale accuracy scores for both groups	66
Figure 2:3: Scores on BSLNST subscales for both groups.....	68
Figure 3:1: Item example from BFRT (correct targets are 2, 5 & 6).....	81
Figure 3:2: Mean accuracy scores of deaf control group and deaf ASD group on the BFRT, error bars represent standard error of the mean.....	82
Figure 4:1: Example of emotional manual signs and facial expressions: HAPPY, SAD and ANGRY	90
Figure 4:2: Angry	94
Figure 4:3: Annoyed	94
Figure 4:4: Disgust.....	94
Figure 4:5: Happy.....	94
Figure 4:6: Mischief.....	94
Figure 4:7: Neutral.....	94
Figure 4:8: Happy masked.....	95
Figure 4:9: Mean accuracy scores for masked and unmasked conditions (error bars represent standard error).....	96

Figure 4:10: Box plot showing emotion recognition accuracy scores per emotion type in the unmasked condition, legend represents first quartile, minimum, median, maximum and third quartile values.....	102
Figure 4:11: Box plot of scores for complex and non-complex emotions in the unmasked condition.....	104
Figure 5:1: Demand.....	117
Figure 5:2: Refusal.....	118
Figure 5:3: Surprise.....	118
Figure 5:4: Mischief.....	118
Figure 5:5: Disgust/Shock.....	119
Figure 5:6: Deaf adult native signer producing facial actions for DEMAND	121
Figure 5:7: Example of deaf adult signer's scoresheet on ELAN.....	122
Figure 5:8 Box plot showing production of different affective facial expression types for deaf ASD and control groups.....	124
Figure 5:9: Box plot showing quality of affective facial expressions produced in the BSLNST	126
Figure 5:10: BSLNST percentiles for deaf ASD and control groups	128
Figure 5:11: Example of deaf individual with ASD producing DEMAND with blank facial expression.....	130
Figure 5:12: Example of deaf control producing DEMAND with identical facial expression	130
Figure 5:13: Example of deaf individual with ASD producing DISGUST/SHOCK with similar facial expression.....	131
Figure 5:14: Example of deaf control producing DISGUST/SHOCK with identical facial expression.....	131
Figure 6:1: Example of Wh question in BSL (WHAT)	141
Figure 6:2: Example of adverbial facial expression and manual sign for DRIVE MM (drive in relaxed manner).....	150

Figure 6:3: Example of negation manual sign NOTHING and facial NMM for negation	151
Figure 6:4: Example of a conditional facial NMM and manual sign RAIN.....	151
Figure 6:5: Example of affective facial expression for surprise and manual sign EARLY	151
Figure 6:6: ELAN coding sheet for facial actions	154
Figure 6:7: Production of linguistic and affective facial expressions in a sentence repetition task for the deaf ASD and control groups	155
Figure 6:8: Proportion of quality scores (%) for linguistic facial expression targets in both groups on the sentence repetition task.	156
Figure 6:9: Proportion of quality scores (%) for affective facial expression targets in both groups on the sentence repetition task	157
Figure 6:10: An example ELAN transcription of a linguistic sentence (e.g. negation) being produced by a deaf individual with ASD in the sentence repetition test.	157
Figure 6:11: An example ELAN transcription of an affective sentence (e.g. SAD) being produced by a deaf individual with ASD in the sentence repetition test	158
Figure 6:12: Example of deaf control producing a linguistic sentence (e.g. FAT-adverbial, No- negation) in the sentence repetition test.....	158
Figure 7:1: Example of manual sign for negation glossed NO accompanied by facial NMM of negation.....	166
Figure 7:2: Example of manual sign for negation glossed VEE accompanied by facial NMM of negation.....	166
Figure 7:3: Example of manual sign for negation glossed NOTHING accompanied by facial NMM of negation.....	166
Figure 7:4: Example of manual sign NIV DON'T KNOW.....	167
Figure 7:5: Example of manual sign NIV DON'T WANT.....	167
Figure 7:6: Manual sign HUNGRY accompanied by facial NMM of negation (no manual sign for negation).....	167
Figure 7:7: Example of response pair positive: negative	179

Figure 7:8: SHOES	180
Figure 7:9: BREAD (positive)	180
Figure 7:10: BREAD face negation	180
Figure 7:11: BREAD NOTHING manual negation.....	181
Figure 7:12: Box plot illustrating the comprehension of face vs. manual negation in the deaf ASD and control groups.....	184
Figure 7:13: Box plot illustrating the reaction time scores for face vs. manual negation in the deaf ASD and control groups	185
Figure 7:14: SLEEP and HAIR.....	190
Figure 7:15: The HEAD masked negation condition.....	191
Figure 7:16: The FACE masked negation condition	191
Figure 7:17: The HANDS masked negation condition	191
Figure 7:18: Box plot illustrating the comprehension of HEAD and FACE masking in face and manual negation conditions.....	194
Figure 7:19: Box plots illustrating reaction time scores for comprehension of the face negation condition over different levels of masking.....	195
Figure 7:20: Example of pair of pictures used in the negation production test	200
Figure 7:21: Box plot illustrating the quantity of negation facial actions produced by both groups	203
Figure 7:22: Box plot illustrating occurrence of negation facial action scores for both groups	204
Figure 7:23: Box plot illustrating quality of negation facial actions produced across groups	205
Figure 7:24: Box plot showing the production of negation facial actions using specific parameters in both groups	206
Figure 7:25: Deaf individual with ASD producing blank negation facial actions with manual sign NOTHING in the negation production test	207

Figure 7:26: Deaf control producing some similar negation facial actions on the negation production test.....	207
Figure 8:1: Example of manual question sign WHAT and facial NMMs for Wh question.....	212
Figure 8:2: Example of facial NMM for yes-no question.....	213
Figure 8:3: Example of yes-no question SQUARE CIRCLE NEXT?.....	219
Figure 8:4: Example of Wh question manual sign RED TRIANGLE WHERE?.....	219
Figure 8:5: Example of command PUT CIRCLE ON.....	219
Figure 8:6: Box plot indicating correct recognition for questions and commands.....	222
Figure 8:7: Example of game board for Guess Who and example of one of the characters	232
Figure 8:8: ELAN scoresheet showing a Deaf adult native signer producing a yes-no question in the “Guess Who” game.....	233
Figure 8:9: Box plot showing quantity of question facial actions produced by both groups during Guess Who.....	235
Figure 8:10: Box plots depicting occurrence of question facial action scores for both groups.....	236
Figure 8:11: Box plot showing quality ratings of yes-no question facial actions during Guess Who.....	237
Figure 8:12: Example of a blank yes-no question "GLASSES? " produced by a deaf individual with ASD during Guess Who.....	237
Figure 8:13: Example of an identical yes-no question "MAN FAT WITH BEARD?" by a control participant during Guess Who.....	238
Figure 9:1: PUFF facial adverbial meaning LARGE or FAT.....	243
Figure 9:2: WALK with MM facial adverbial meaning with relaxation	244
Figure 9:3 Example of English mouthing across the three photographs produced with the sign DOG.....	245
Figure 9:4: Adverbials MM (left) DRIVE IN A RELAXED WAY and TH (right) DRIVE CARELESSLY.....	246

Figure 9:5: FINALLY manual sign with PU mouthing.....	248
Figure 9:6: FINALLY manual sign with corresponding English mouthing.....	248
Figure 9:7: INT (effort) adverbial facial expression for manual sign PUSH.....	255
Figure 9:8: THIN manual sign and facial adverbial (PS).....	256
Figure 9:9: THICK manual sign and facial adverbial (CHA).....	256
Figure 9:10: CARRY (with effort) (INT).....	257
Figure 9:11: Example pictures from adverbial comprehension test for CARRY BOX INT (left) and CARRY BOX MM (right).....	257
Figure 9:12: CARRY (with ease) (MM).....	258
Figure 9:13: MOW LAWN (with effort) (INT).....	258
Figure 9:14: MOW LAWN (with ease) (MM).....	258
Figure 9:15: RUN (INT) (with effort) adverbial information on face alone.....	259
Figure 9:16: LAPTOP THIN (PS) adverbial information on hands+face	260
Figure 9:17: Box plots illustrating accuracy scores (%) of adverbials on the face alone and hands+face in both groups.....	261
Figure 9:18: Box plots of reaction time scores for adverbial on ‘face alone’ and ‘hands+face’ conditions for both groups.....	262
Figure 9:19: Images used for adverbial production test.....	265
Figure 9:20: Example of ELAN score sheet of deaf adult signer producing an adverbial facial action (TH) in the adverbial production test for MAN DOG DRAG	266
Figure 9:21: Box plot showing percentage (%) of adverbial facial targets produced.....	269
Figure 9:22: Box plot showing frequency of adverbial facial actions for both groups.....	271
Figure 9:23: Box plot showing quality ratings of adverbial facial actions in the adverbial production test.....	272
Figure 9:24: Example of a control participant producing an identical ‘effortful’ adverbial facial action for MAN CARRY WEIGHT INT.....	273

Figure 9:25: Example of a deaf individual with ASD producing a blank ‘effortful’ adverbial facial action for MAN CARRY WEIGHT INT.....273

Figure 9:26: Example of a deaf individual with ASD producing a blank ‘effortful’ adverbial facial action for MAN CARRY WEIGHT INT.....274

Figure 10:1: Summary graph of mean comprehension scores (%) for linguistic facial expression tasks (* illustrates significant difference between groups).....282

Figure 10:2: Summary graph of mean production scores (%) for linguistic and affective facial expressions (* illustrates significant difference between groups).....283

Figure 10:3: Diagrammatic representation of impaired and unimpaired facial actions in BSL in deaf individuals with ASD (intersections represent impaired abilities).....290

Chapter 1: Do deaf children with Autism Spectrum Disorder (ASD) show deficits in the comprehension and production of emotional and linguistic facial expressions in British Sign Language?

Literature Review

Definitions, prevalence and co-occurrence: ASD and deafness

ASD

Individuals with ASD are characterised by a triad of impairments, consisting of: social, verbal and non-verbal communication and imaginative activities (Diagnostic and Statistical Manual for Mental disorders, DSM IV, American Psychological Association, APA, 1994 and International Classification of Diseases, ICD 10, World Health Organization, WHO 1992). Social impairments include lack of interest in others, the inability to interact appropriately with others using social norms and a failure to develop friendships.

Communication impairments range from a delay in language acquisition to a complete failure to develop language. The language of individuals with ASD is often varied between individuals but notable impairments include: prosodic difficulties (such as unusual intonation and pitch); pragmatic difficulties (turn taking, relevance of topic and understanding indirect language) and echolalia (repetition of sentences or phrases in an unusual manner). Non-verbal communication is also impaired with little use of gesture and eye contact when communicating with others. Deficits in imagination are manifested through a limited use of pretend and imaginative play.

Autism lies on a spectrum and affected individuals fall across continuums of intelligence and language ability and severity of autistic traits. Asperger's syndrome refers to individuals with the typical social communication impairments of autism but who nevertheless have fluent language and no delay in cognitive development (Hill & Frith

2003). In ASD basic social impairments are inherent early in development, lack of attention to others can be observed in the first year of life (Werner et al., 2000). By the time children with ASD reach the age of 2-3 years, an increasing number of social and communicative impairments are apparent (e.g. in social orienting, eye contact, joint attention, imitation and face recognition, (Mundy et al., 1990; Dawson et al., 2004)). A key element of these deficits appear to be related to marked impairments in the use of eye gaze and facial expressions in social interactions (APA, 1994).

The estimated prevalence for ASD varies depending on the place, time, and population from which the estimate is calculated (Prior, 2003). Several different recent studies have reported widely different figures. For example the British Medical Research Council (2000) stated that on average 1 per 1000 children has a diagnosis of autism and 2.5 per 10,000 have a diagnosis of Asperger's syndrome. Fombonne (2005) conducted a meta analysis, reviewing epidemiological surveys in the UK and US and concluded that the prevalence of ASD is 13 per 10,000. Whilst a more recent figure from the Center for Disease Control and Prevention (Kogan et al., 2009) in the US suggests that the prevalence of ASD in children is approximately 1 in 91.

Diagnosing ASD in deaf children

There are currently no standardised psychometrically validated assessments for diagnosing ASD in deaf children. The Autism Diagnostic Observation Schedule Generic (ADOS-G) (Lord et al., 2000) is one assessment, which is used widely for confirming diagnoses of ASD in hearing individuals. It is appropriate for children who range in language ability from non-verbal to fluent (using different modules for varying language fluency levels). However its guidelines state that it is not recommended for use with deaf children. Many

other checklists which assess symptoms of ASD assume the child can hear and include unsuitable items which discriminate against deaf people (e.g. the Children's Communication Checklist) "*Does the child respond to their name being called?*" (Bishop 1998; Scawin 2003) Diagnostic classification criteria can also be inappropriate for deaf people. The DSM-IV (APA 1994) suggests a diagnosis of ASD may be given when there is 'a delay in or total lack of development of spoken language' in addition to the presence of other risk markers. However for deaf people having a lack of spoken language or delays in acquisition is the norm. There are many other issues that need to be considered when assessing pre-lingually profoundly deaf people for ASD. Tests may need to be modified because they are based on auditory or verbal items (e.g. a child's response to their name being called out in the ADOS-G). These tests may artificially deflate the scores of deaf children. Many diagnostic measures are also inappropriate due to a reliance on descriptions of the subjective experiences of the individual who is being diagnosed (Bradley et al., 2004). This is problematic, as children who are deaf may have difficulty sharing this information with others (e.g. parents, clinicians etc) because of communication barriers or language difficulties. Therefore deafness and consequently language delay may also mimic or mask ASD. It is not surprising then that autism diagnosis in deaf children is inaccurate with a greater occurrence of missed diagnoses and false positives.

Therefore without specific tests or objective criteria to follow, clinicians may rely only on clinical judgment. This is problematic for clinicians with insufficient specialist knowledge of deafness, without the clinical experience to decide whether a child's language and social abilities are sufficiently more delayed or disordered than would be anticipated for a healthy deaf child. This requires thorough knowledge of effect of

communication abilities, language input, degree of hearing loss and non-verbal ability in deaf children generally as well as fluency in British Sign Language (Edwards & Crocker 2008). In the UK there are only a handful of paediatricians with specialist expertise and even then diagnosis is ad hoc and reliant on subjective clinical opinion. For the thesis, the deaf ASD group were recruited through the deaf child young person family service (DCYPFS) (see chapter 2 for description of their diagnostic procedures) to minimise the possibility of individuals being recruited who have been wrongly diagnosed. Similarly the social responsiveness scale (SRS) (Constantino & Gruber, 2005) was given to controls to exclude participants in the control group who had a number of language and social difficulties, which may have led to a later autism diagnosis.

Deafness

Individuals described as being deaf can range from having a partial to a complete hearing loss. For the purposes of the current thesis, only severe (71-90 dB) to profound (91+ dB) deafness will be described. Individuals with severe or profound deafness often communicate using British Sign Language (BSL) as a preferred language. There are approximately 50,000-70,000 profoundly deaf people in the UK and just as many users of BSL (Department of work and pensions, 2007). The Royal National Institute for the Deaf (RNID fact sheet, 2005) states that deafness affects one person in seven, however this figure is thought to incorporate all types of hearing loss from very mild to temporary deafness and is unlikely to be a true reflection of the population of deaf BSL users in the United Kingdom.

Co-morbidity of ASD and deafness

Several prevalence studies demonstrate the co-morbidity of deafness and ASD (Jure et al., 1991; Rosenhall et al., 1999; Roper et al., 2003). Jure et al., (1991) measured the prevalence of ASD among 1150 children who had been diagnosed with a hearing impairment over a 10 year period. One group of children were assessed who attended St Josephs school for the deaf in the Bronx (n=387), these were 'normal' severely to profoundly deaf children, another group were seen who had been given a private neurological consultation who had complex conditions (n=277) and 486 children were referred to the Auditory Evoked Response Laboratory to receive audiological testing, this latter group consisted of several individuals with multiple conditions. From assessments of all of these individuals, 46 (4%) were found to have an additional diagnosis of ASD. One methodological problem with this study was the heterogeneous sample of children recruited, a large proportion had a higher rate of additional disabilities than is usually found in the deaf population (e.g. 35% of the children had visual impairments and 17% had epilepsy). This suggests that the sample may not have been representative. These are the only prevalence figures in deaf children to date. On the other hand Rosenhall et al., (1999) carried out audiological assessments on a smaller group of 199 children and adolescents with ASD, they found 19 (9.5%) had hearing impairments of differing severity. It has been argued that hearing impairment is much more common amongst individuals with ASD than it is in the general population. Gillberg and Bildstedt (2000) claimed that 10-20% of all classic cases of ASD have moderate to severe or profound hearing deficits. Zimmerman (2005) concurred with these findings reporting that congenital hearing loss is the most frequently co-existing condition that occurs with ASD.

Neuropsychological studies provide further evidence in favour of an increased prevalence of deafness and ASD. Gillberg et al., (1990) conducted a longitudinal clinical study of 20 children with ASD who were 3 years old and under. Each child was given thorough hearing, neurobiological and psychological assessments. Six children (30%) were found to have moderate to severe conductive hearing deficits. Steffenburg (1991) completed neuropsychiatric assessments on a group of children with ASD. They found that 8 out of 38 (21%) children with ASD had some form of hearing impairment. It is important to note that despite the suggestion that hearing impairment and ASD are linked in some way, there are no correlations between severity of hearing impairment and number and strength of symptoms associated with ASD (Rosenhall et al., 1999). However it is likely that this higher prevalence of hearing loss in ASD may contribute further to the social and communicative difficulties demonstrated in individuals who have both diagnoses (Stoddart et al., 2003).

These prevalence studies should be treated with caution due to methodological limitations. Problems with generalisability include the use of: different inclusion criteria; small sample sizes; mixed age samples and repeated measures. There is a risk of sampling bias, since participants with deafness and ASD are more likely to have severe needs than individuals with only one diagnosis and are therefore referred to clinics more often. This may cause an overestimate of the prevalence of deafness and ASD (Tomblin, 2009).

There are no studies which distinguish the proportion of severely or profoundly deaf sign language users with ASD. A more recent attempt at predicting the prevalence of deafness and ASD in this subgroup was carried out by researchers at Gallaudet University in America (Szymanski & Brice 2008). They avoided the aforementioned methodological

issues by creating a survey which sought to determine how many deaf and hard of hearing young people were in special education programs. They received 35, 706 complete responses and found that 469 of these were found to have an additional diagnosis of ASD. Based on these figures Szymanski and Brice (2008) concluded that one deaf or hard of hearing child in 76 was receiving specialist services for having deafness and ASD. This number may be an underestimate, as the survey did not include every deaf child in America, only those who were receiving special educational services and would not have included children with high functioning ASD in mainstream schools. These findings only represented children who had clinicians, teachers or parents who took the time to complete and return the survey.

In spite of these findings with research pointing to a higher incidence of ASD in deaf children compared to the general population, “there is a dire lack...of research and information concerning deaf children on the autism spectrum...also a lack of resources, services, training and programs” (Ellis-Gonzales, 2008, p27). This is slowly being addressed with an increase in researchers paying attention to this population.

Problems with diagnoses of deafness and ASD

Prevalence rates may vary due to the difficulty of diagnosing hearing impairments in individuals with ASD and with diagnosing ASD in deaf children. Children with ASD often pay little attention to auditory stimuli and are consequently described as being ‘functionally deaf’ (Bogdashina 2003). Individuals with ASD are also often over or under sensitive to sensory stimuli such as sounds in the environment, and this may lead to primary hearing loss being overlooked in ASD (Carvill, 2001). These findings suggest that the symptoms of ASD may mimic or mask deafness, leading to diagnostic uncertainty.

Individuals with ASD may not cooperate with hearing assessments which may distort measurements of hearing loss. Individuals with more severe symptoms of ASD have lower accuracy on psycho acoustical tests. Rosenhall et al., (1999) needed to retest 17 patients over three times. The development of newer technologies may resolve this problem, as less invasive methods of assessing hearing (which do not require overt responses) are being used (e.g. the Universal Newborn Hearing Screening Programme (UNHSP) launched in the National Health Service, NHS in 2008).

Face processing impairment in ASD

There is a large body of evidence suggesting that individuals with ASD have a general face processing impairment, with difficulties with both attending to and recognizing information from the face (Klin et al., 1999; Schultz et al., 2003; Dawson 2005). Individuals with ASD show deficits in holistic processing of faces, Joseph and Tanaka (2002) compared individuals with ASD with typically developing controls on a composite face task. Participants were required to recognize facial features either presented in isolation or in the context of a whole face. Controls demonstrated a whole face advantage, whereas individuals with ASD only showed this advantage for the mouth and were impaired at recognizing the eyes in a whole face context.

It has also been suggested that individuals with ASD do not show the same propensity as individuals without ASD to process faces differently to non-face objects (Schultz et al., 2000; Sasson 2006). Their brains do not treat faces as 'special' in the way that healthy controls do. Bird et al., (2006) explored this hypothesis, they compared an ASD group to typically developing controls on attention to faces and houses in two different tasks using functional magnetic resonance imaging (fMRI). During a single

presentation task, participants had to judge whether face or house stimuli were the same or different by pressing one of two response keys. In the second paired task, one of the pairs was randomly assigned to an attended location and the other to an unattended location in every presentation. Neural activation to individually presented house and face stimuli were the same across participant groups. However there was a significant difference between groups in the second task (involving paired presentation), with a lack of attentional modulation for face-selective regions in ASD. The controls in contrast had activation of both face selective regions and object regions during this task. These findings demonstrate that social stimuli are less salient in individuals with ASD.

Wallace et al., (2008) compared individuals with ASD and typically developing controls on two tasks: Firstly, a measure of holistic processing involving decisions about whether two items in a pair (pictures of faces and cars) were the same or different based on holistic properties. The second task required a similar judgment based on featural properties of faces and houses. (This consisted of changes being made to the features of a face or house so that the mouth was moved further away from the nose or the windows were moved higher away from the door.) Participants were presented with a picture of a face or a house and another picture immediately after in rapid succession and they had to determine whether the spatial properties of both pictures were the same or different based on their featural properties. Individuals with ASD were impaired in discriminating between faces in both tasks, but showed no difficulty making the same judgments for objects. Klin et al., (2003) suggest that the typical overriding salience of social stimuli is not present in children with ASD, instead physical stimuli are more likely to attract the child's selective attention leading to greater specialization for objects rather than people.

Several research studies have demonstrated that face processing impairments manifest in individuals with ASD due to an unusual visual scanning of faces (Klin et al., 2002; Pelphrey et al., 2002; Dalton et al., 2005). “Individuals with ASD exhibit grossly abnormal gaze behaviour when viewing face information” (Riby & Hancock, 2009, p422). Pelphrey et al., (2002) compared the visual scan paths of adults with ASD and typically developing controls. Participants looked at pictures of static faces and were either instructed to look passively or to actively identify emotions. Looking behaviours differed significantly between groups. The scan paths of the ASD group were undirected and focused on unimportant parts of the face whereas the controls scan paths were strategic and traced a triangle covering the eyes, nose and mouth. This suggests people with ASD show abnormal strategies when looking at and processing faces. Klin et al., (2002) measured eye movements of high functioning individuals with ASD whilst they watched a videotape of actors in a social situation. Controls attended to the eyes of the actors and their gaze cues, while individuals with ASD showed a tendency to fixate on the mouth of the person who was speaking. These findings suggest that there is an unusual privileging of the mouth by individuals with ASD. This may result from an aversion to looking at the eyes when looking at faces.

Neuro-imaging studies corroborate an unusual scanning of faces in ASD. Gaze fixation and neural activation were measured during facial discrimination tasks (Dalton et al., 2005). The ASD adolescent group showed a different pattern of scanning and processing faces compared with typically developing age-matched controls. There was a correlation between the length of time the ASD participants fixated on the eye region of faces and fusiform gyrus activity as measured by fMRI. Variations in gaze fixation (i.e.

scanning the face) were also correlated with amygdala activity. Neither of these correlations were found for the control group. Thus the regions of the brain implicated in heightened emotional response are activated for individuals with but not for individuals without ASD. This suggests that gaze fixation in ASD may be experienced as an anxiety-provoking event and therefore individuals with ASD may look less at faces in order to protect themselves from aversive over arousal.

Investigations of gaze during emotion judgement reveals individuals with ASD show abnormal patterns of attention to the eyes and mouth relative to controls (Spezio et al., 2007). Eye tracking was combined with a bubbles method (Gosselin & Schyns, 2001), which manipulates the amount of facial information shown on different trials, so only small amounts of the face are presented at a time. This provided a sensitive measure of behavioural anomalies. Individuals with ASD showed differential processing of faces with fewer fixations to the eyes and mouth. Additionally when information was presented in the eye region they showed a greater tendency to saccade away from the eyes. Taken together the body of relevant research suggests that individuals with ASD present with abnormal face processing ability. Typically these impairments consist of reduced attention to the face and an aversion to the eyes.

An alternative view posits a general 'lack of interest' to faces in autism, rather than an unusual attention pattern. This is often evident from a very young age (Baron-Cohen et al., 1996). Swettenham et al., (1998) compared young infants with ASD with typically developing controls during social interactions. Infants with ASD attended to people less than objects demonstrating an early aversion to faces. Riby and Hancock (2008) tracked eye movements in individuals with ASD, Williams syndrome and typically developing

individuals whilst viewing faces. The ASD group spent the least time looking at faces. The 'lack of interest' hypothesis is also supported by Chawarska et al.,'s (2010) findings of disengagement from faces in toddlers with ASD. They compared toddlers with ASD, developmental delay and controls on their attention to faces using a cued attention task with facial and non-facial stimuli. Disengagement occurred when participants fixated on the central cue and resulted in failure to make a saccade to the target cue. Disengagement from facial stimuli was measured for all groups using saccadic reaction times. The ASD group did not show the difficulty disengaging attention from faces which manifested in the other groups, suggesting that they are not drawn to look at faces in the same way. Early assessments of children subsequently diagnosed with ASD show marked delays on social milestones that involve looking at faces (Mundy & Neal, 2000) and many retrospective studies of early markers of ASD flag up a lack of looking at the face or failure to maintain eye gaze as early signs for ASD in development. These markers are observed in 12 month olds in home video tapes, who are diagnosed with ASD at a later date (Osterling & Dawson, 1994; Baranek, 1999).

Dawson (2005) suggested that face processing impairments in ASD are related to difficulty in forming representations of the reward value of social stimuli. Individuals with ASD attend to faces less because they do not find them interesting leading to decreased cortical specialization and abnormal brain circuitry for face processing. This explanation accounts for neuro-imaging findings of decreased activation in face processing areas in the brains of individuals with ASD (Schultz et al., 2000). However there is no clear evidence, for whether face processing is directly impaired at a neurobiological level as a result of ASD, or whether impairments seen arise over development due to a lack of interest and

attention to faces in ASD. These findings of reduced attention to faces in individuals with ASD have important implications for the development of social skills in ASD. If individuals with ASD spend less time attending to faces then they will be less skilled at deriving social communicative information from others faces (Riby & Hancock, 2009). As deaf individuals need to attend to faces to communicate and they use facial aspects of grammar in sign language, it is of interest to see how deaf individuals with ASD will use the face in sign language. Will this experience with faces through sign language counter the 'lack of interest' hypothesis that is associated with hearing individuals with ASD?

Theory of Mind

Another characteristic impairment that is associated with ASD is Theory of Mind (ToM). It involves the ability to form representations of other people's mental states and to use these representations to understand, predict and describe the behaviour and motivations of others (Brownwell & Martino, 1998). An overarching deficit in ToM (also sometimes described as mentalising) might account for the pattern of impairments seen in communication, socialisation and imagination that characterise ASD (Frith, 1989). The ToM hypothesis suggests that an absence of ToM is a fundamental deficit in ASD (Baron-Cohen et al., 1985; Leslie & Frith, 1987; Frith, 1989; Leslie & Happe, 1989). ToM is classically tested by using false belief tasks, since the ability to ascribe false beliefs to others is considered to encapsulate ToM ability. There are two common types of false belief task: 1) Change of location tasks (e.g. The Sally Anne task, Wimmer & Perner, 1983; Baron-Cohen et al., 1985) and 2) Unexpected contents tasks (e.g. the smarties tube task, Wimmer & Perner, 1983; Perner et al., 1987). The Sally Anne task tests children's understanding of a role-play situation where a doll moves a marble from one basket to another, while another doll is

absent from the room. Children are asked where the absent doll will look for the marble. Typically developing children under 4 years old fail this task by selecting the basket that the other doll has moved the marble to rather than the original location. This demonstrates that they do not understand that the absent doll's beliefs are different to their own. At 4 years and above typically developing children pass this task by selecting the original location. By contrast, Happe (1995) showed that a verbal mental age of 8 years or above is necessary for children with ASD to pass this test.

Typically developing children aged 5-8 years typically acquire more advanced concepts such as deception, whereas these milestones are absent or severely delayed in individuals with ASD (Frith, 2001). Some children with ASD do pass basic ToM tests, however they tend to fail more sophisticated versions of false belief tasks (Baron-Cohen et al., 1985). Second order false belief tasks measure what one person thinks about another person's belief and involve an extra level of understanding. Wimmer and Perner (1983) found that typically developing children pass second order false belief tasks once they reach the age of 7 years old. However children with ASD tend to fail these tasks, even when they are capable of passing easier first order false belief tasks (Baron-Cohen et al., 1985).

A ToM deficit could account for the language impairments seen in ASD, as children with ASD often only express their own needs and interests at the expense of their listener, which reflects a lack of understanding of the needs and beliefs of the person with whom they are speaking. Individuals with ASD often fail to use mental state terms when talking to others and Tager Flusberg and colleagues (1981b; Tager Flusberg & Sullivan, 1994; Tager Flusberg, 2003) suggest this reflects a ToM deficit in ASD. Neurological evidence for a

ToM deficit in ASD comes from Frith (2001) who found under activation in brain regions which are recruited for ToM in individuals with ASD (e.g. the medial prefrontal cortex, the temporal parietal junction at the top of the superior temporal sulcus and the temporal poles next to the amygdala).

One caveat for the ToM explanation is that many individuals with ASD are still able to pass false belief tasks. Bowler (1992) found that 73% of individuals with ASD passed complex ToM tests. This suggests that ToM may not be the sole explanation for social impairments in ASD, rather it may be one cause (Hulme & Snowling, 2009).

Is there a relationship between face processing impairments and ToM?

Baron-Cohen et al., (1995) stated that impaired eye contact may be linked to ToM deficits in children with ASD, as they do not understand the significance of other people's eyes as a source of mental state information. However more broadly speaking the role of ToM deficits in accounting for a face processing impairment in individuals with ASD is unknown. The fact that there are individuals with ASD who pass ToM tasks yet still have difficulty with affective information in the form of recognising emotions from faces or voices (Tager-Flusberg, 2007) does not support this relationship. Hobson (2005) suggests a superordinate link between emotions and ToM, proposing a model of social-affective justification, in which ToM deficits arise as a result of inability to understand and respond to emotions (which may or not be manifested through face processing).

Limited neuroimaging findings indicate dysfunction not only within neural systems important for face processing but also within regions underlying higher-order cognitive functions, including ToM (Frith, 2001). This supports a link between face processing and ToM in social cognitive networks in ASD.

The mirror neuron system (MNS) is a region in the brain located in the inferior frontal and parietal regions that responds to actions of the self and others. Evidence suggests that it is impaired in individuals with ASD (Dapretto et al., 2006; Hamilton et al., 2007; Oberman & Ramachandran, 2007). MNS dysfunction in ASD has been demonstrated by neuroimaging studies (e.g. Electroencephalography, EEG) showing that action units do not fire in regions of the MNS in individuals with ASD when observing others perform actions (Oberman et al., 2005; Raymaekers et al., 2009). However an opposing view comes from Southgate and Hamilton (2008), they argue that the MNS hypothesis is not valid in ASD (see chapter 10 for further details). The existence of MNS dysfunction in ASD remains controversial with some authors unconvinced (Southgate and Hamilton, 2008; Dinstein et al., 2008).

The MNS could be implicated in face processing, as individuals with ASD who have impairments perceiving the actions of others, cannot be expected to learn facial expressions by observing or imitating the expressions that others produce. Some researchers extend these impairments perceiving actions of others to difficulties with abstract reasoning about the actions and intentions of others, postulating that deficient MNS may account for impaired ToM (Dinstein et al., 2008), however evidence regarding the MNS in accounting for ASD and features associated with a diagnosis of autism (e.g. face processing and ToM impairments) is speculative at best. However a superordinate neurobiological impairment might explain impairments characteristic of ASD (e.g. face processing, ToM and imitation). The precise interaction between all three of these components needs further attention.

Characteristics of sign language

In order to ascertain whether the facial impairments typically seen in ASD impact on abilities in BSL, it is necessary to go into detail about general characteristics of BSL particularly in structures that rely on the face. It is now widely accepted that sign language is a true language (Messing & Campbell, 1999). There are many strong similarities between spoken and signed languages in grammatical structures, acquisition and the way they are processed (Sutton Spence & Woll, 1999). BSL has its own lexicon and grammar with rule governed phonology, morphology and syntax (Meier, 2002). Despite these similarities the nature of communication for deaf people who use sign language is very different to that of hearing people who communicate using speech. Sign languages differ in modality to spoken languages, exploiting the visual manual channel (Sandler, 2006). Signs are produced by the hands and perceived by the eyes and require sustained visual attention to the hands and face for signal input (Liddell, 1980). Modality influences morphology (Sandler & Lillo-Martin, 2006). For example sign language produces its meaning and syntax using multiple channels: hands, face, head movements and body postures. The hands are the main articulator and produce information through variations of phonological parameters of handshape, movement and location (Morgan & Woll, 2007). The face is another crucial articulator, facial actions are used to supplement the information on the hands. The face and hands work simultaneously to produce rich morphological inflections such as negation and adverbs and also to signal questions (Roberts & Hindley, 1999). This stands in marked contrast to spoken languages which rely on the mouth and tongue to articulate speech, albeit with some simultaneous facial expressions, however these are

largely affective and sequential acting as an aid to prosody and are not regularised or rule governed in the way that facial actions are in signed languages.

Facial expressions have several roles in BSL. They convey the same emotional information (e.g. happiness, surprise, fear) as they do in spoken language but they also have linguistic functions. Linguistic facial actions are known as non-manual markers (NMMs). NMMs are crucial grammatical markers as when they are produced in conjunction with a single sign phrase they change the meaning from an assertion, to a question, a statement of negation or a relative clause simply by varying the type of facial action produced (Liddell, 1980). For example, raising the eyebrows can turn a statement into a question. A head shake will turn a statement into a sentence with negative meaning, conveying the absence of something. Baker and Padden (1978, p28) stated the face is fundamental to sign language since “the activity of the eyes, eyebrows, and mouth are paramount and without them, much of what the hands are saying would be ambiguous”. They are therefore mandatory for the comprehension and production of sign language. Facial actions occur in many linguistic structures in sign language such as: *Negation*: a sentence stating that something is not the case (Sutton-Spence & Woll, 1999), negation can be expressed by a lexical/manual sign (NOTHING, NO) and obligatory non-manual facial features consisting of a short lateral head shake, furrowed brows, narrowed eyes and a down turned mouth (Atkinson et al., 2003, see Figure 1:1). Negation can be produced with facial actions alone or facial actions and manual signs. *Conditionals*: in a conditional sentence first the condition is described and then an outcome (e.g. SUPPOSE TONIGHT SNOW, TOMORROW YOU CANCEL SCHOOL) (Stewart 2006). Facial signals are critical in conditionals, they are marked by eyebrow movement, head tilts or they can be lexically

marked using a sign or finger spelling of the English word 'IF'. Different types of questions are distinguished by different facial actions which cue the response required: *Yes-no questions*: are closed questions requiring only a yes or no, they are indicated with raised eyebrows and widened eyes (see Figure 1:2) and *Wh-questions*: (WHAT, WHEN, WHERE, WHO) which are open questions, they have furrowed eyebrows, slightly closed eyes and a forward or slightly tilted head movement (Sutton Spence & Woll, 1999, see Figure 1:3). Different types of question cue the response type that is required by the communicative partner. For example Deuchar the British linguist stated that “the facial expression is not so much a distinction between Wh and yes-no questions, as between ones which request a lot of information and those which do not” (Sutton-Spence & Woll, 1999, p68).

Other uses of the head and face serve pragmatic functions for example head nodding in BSL, indicates that the signer is paying attention, looking away from a communicative partner briefly whilst signing indicates that the signer is thinking and does not wish to be interrupted (Sutton Spence & Woll, 1999). The mouth has several functions in BSL. Mouthings occur when an English word is borrowed from spoken language. It is either produced in full or partially alongside a manual sign to facilitate comprehension or to distinguish between sign homophones. Mouth gestures differ from mouthings as they are not influenced by spoken English and are unique to BSL. One type of mouth gesture involves the production of a specific mouth shape which is associated with a sign (e.g. PAH in ASL/ PU in BSL is associated with the sign FINISH) (Bickford & Fraychineaud 2008) (see Figure 1:4). Other types of mouth gesture are independent of specific signs, providing adverbial information about the manner or effort of an action (e.g. in BSL mouthings

accompany a verb such as DRIVE, WRITE, JUMP to indicate different types of action) or the size of an object (e.g. THICK BOOK, Sutton Spence & Woll,1999).



Figure 1:1: NOTHING manual sign and facial NMM for negation



Figure 1:2: Facial NMM for yes-no question



Figure 1:3: WHAT manual marker and facial NMM for Wh question

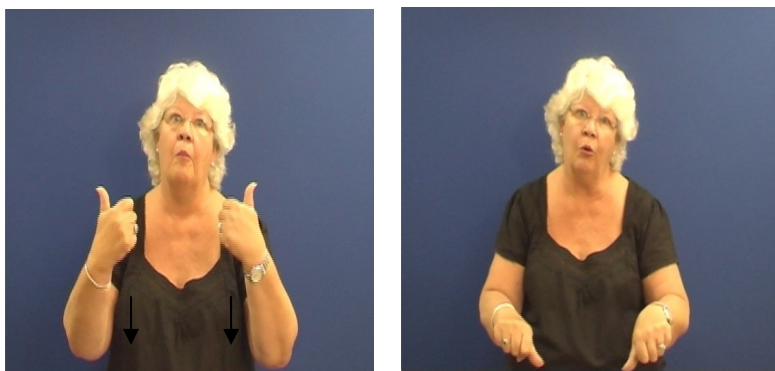


Figure 1:4: PU mouth pattern which is produced with the sign FINALLY

Eye gaze has several roles in sign language, it is used to mark role shift changes in a story, mark time, invite signers to a conversation and contrast real from rhetorical questions (Sutton-Spence & Woll, 1999). Hearing people can follow spoken conversations without focusing on the speaker's face and tend to look only for emotional information or clarification of meaning. In sign language it is compulsory that deaf signers look to the face of signers for grammatical, emotional and discourse information (Grossman & Kegl, 2007). Deaf signers maintain eye contact for longer during conversations than hearing speakers of English, indicating greater focus on their conversational partners face (Grossman & Kegl, 2007; Jeffrey & Austen, 2007). Deaf people perceive the disruption of eye contact during conversation to be impolite, as this disrupts the transmission of signed information (Jeffrey & Austen, 2007). A number of studies provide evidence that deaf signers fixate on the lower face rather than the hands when comprehending sign language. Muir et al., (2006) tracked eight deaf BSL users' eye movements whilst they watched short video-clips in BSL. The range was between 61-99% focused on the face with occasional saccades away from the face to the hands. Deaf people maintain concentration on the faces of signers as it carries rich emotional and linguistic information and provides important speech reading and

eye gaze direction cues. Agriofiotis (2006) looked at the relationship between level of skill in BSL and attention to the face during sign comprehension. The eye gaze of 5 participants was tracked, some were deaf (expert signers, n=3) and some hearing (naïve beginners, n=2), they revealed that experienced sign language users fixate on the face of the signer, especially the mouth, with no fixations on the hands. Naïve viewers tend to visually track the hands and have a spread gaze pattern looking from hands to face when viewing BSL. These findings suggest that attending to the face may impact on sign skill.

Acquisition of sign language

Developmental research largely shows that children acquiring sign language from signing parents achieve the same broad milestones in parallel with hearing children learning spoken language (Reilly 2006). However, despite linguistic structures occurring in a different modality, there are interesting differences because a child learning to sign must recruit multiple channels including the hands, face, head, shoulders and eyes. Certain cognitive prerequisites are required before NMMs in BSL are fully mastered (Reilly, 2006). For example question manual signs first appear at 1;6-2;4 years, whereas co-occurring question non-manual facial actions do not appear until 3;6 years and are not fully mastered until 6;0 years (Mayberry & Squires, 2006). Additionally, deaf infants need to acquire both emotional and linguistic facial expressions to distinguish their different functions. Studies of ASL acquisition demonstrate that for deaf children learning ASL manual signs take precedence over non-manual signs initially. This suggests that deaf children use lexical strategies initially prior to complex facial morphology. Deaf children also acquire linguistic facial behaviours (e.g. negation NMMs) separately to emotional facial expressions, i.e. they are unable to recruit their pre-linguistic communicative forms for example an eyebrow

furrow for puzzlement for linguistic purposes when producing Wh questions (Anderson & Reilly, 1998) suggesting that linguistic and communicative facial expressions use separate systems in sign language acquisition (see chapters 7-9 for further details).

Sign Language and ASD

The unique features of sign language provide a window of opportunity to look at what happens to acquisition when signers have weak face processing abilities. There is no published research looking specifically at face processing in ASD and its impact on sign language abilities. A majority of the literature describes individual case studies of low functioning individuals with limited language skills. One case study was of an 11 year old deaf girl with ASD “PB” who rarely made any attempts to communicate with others and mainly expressed herself with self-harming behaviours (Denmark, 1990). Hindley (2000) carried out an assessment of a 6 year old deaf boy with ASD and additional learning disabilities noting that he had no functional language, echolalia and marked challenging behaviours. It is possible that deaf native signers with ASD may have better communicative abilities because native signers receive early exposure to sign language unlike the 90% of deaf children who are born to hearing parents and face language delays. Poizner et al., (1990) reported a single case of a deaf native signer with ASD “Judith” who had been exposed to sign language from birth through communication with her deaf parents. Therefore Judith had a good opportunity to learn sign language at an age appropriate developmental level. Nevertheless she demonstrated clear signing deficits, which were associated with her diagnosis of ASD. Judith’s signing was far from fluent, and was marked by a lack of grammatical structures with effortful and awkward single sign production. The majority of signs that Judith did produce were echolalic or meaningless

repetitive gestures. Judith rarely made eye contact during interactions and she showed a distinct absence of facial expressions and gesture in her signed output. Communication was only initiated to request basic needs. Malandraki & Okalidou (2007) studied a 10 year old deaf Greek boy with deaf parents who had a diagnosis of ASD: “C.Z”. He was unable to communicate with others successfully using sign language, despite the fact that he had been exposed from birth. These studies suggest that deaf native signers with ASD still demonstrate communicative impairments. These studies on deaf individuals with ASD to date face a number of methodological weaknesses: 1) they are subjective 2) they may not be generalisable to a larger group 3) they are based on low functioning individuals and 4) they lack sufficient detail (for example little is mentioned about severity of autistic symptoms and language level via detailed linguistic analysis).

To date research studies paint a bleak picture of the communicative abilities of deaf individuals with ASD, however Jure et al., (1991) demonstrated a wider range of language ability in their sample. They looked at language ability in a group of hearing impaired children with ASD who had received sign language training. Seven of these children had marginally adequate sign language comprehension skills. Four produced sign language at a phrase level, three signed at a single word level and five signers merely showed echolalia in their sign production.

Describing linguistic features of autistic signing is hampered by low baseline ability. Those signers have gross communication impairments which preclude the acquisition of multi channel features in sign language. The signing of higher functioning individuals where language abilities are better developed would be more fruitful in

allowing us to track the subtle relationships between face processing ability and mastery of sign language structures that rely on the face.

Teaching sign language to hearing individuals with ASD

There is a significant body of research relating to sign language as a communication strategy for hearing non-verbal individuals with ASD as part of broader augmentative and alternative communication therapies (AAC) (Bonvillian et al., 2001). During the 1970s several studies investigated the benefits of using sign language instruction with hearing non-verbal children with ASD (Bonvillian & Nelson, 1976; Fulwiler & Fouts, 1976; Bonvillian & Nelson, 1978; Bonvillian et al., 2001) claiming advantages including improved communication, reduced frustration, increased social and adaptive behaviours and facilitation with the acquisition of spoken language skills. Webster et al., (1973) suggested improved use of the face in communicative ways as a result of learning sign language. They reported the case of a hearing 6 year old mute child with ASD who readily acquired a number of signs and was able to give commands. They noted that he attended to facial expressions to a much greater extent. Fulwiler and Fouts (1976, p45) stated that “the face is the focal point, it carries most of the burden of enriching the signs... the face expressions are vital to communicative process, hence the child learns to attend to facial expressions and maintain eye contact”. Therefore a benefit of using sign language with children with ASD may be increased attention to facial expressions because of the rich information that they carry in sign language. Alternatively sign language may be easier to learn for individuals with ASD due to a preference for the visual modality or over sensitivity to sound. The most likely explanation is that signs can be slowed down and moulded. Signing speed is only half as fast as the production of vocalisations (Bellugi &

Fischer, 1972). This means visual feedback can be given to the children as they produce a sign. Children with ASD often need repeated presentation, hand moulding and prompting with cues before they produced signs themselves (Bonvillian et al, 2001). Tardif et al., (2007) found slowing down certain types of stimuli facilitates performance in ASD. Face recognition and imitation improved in moving faces or sounds were slowed.

Konstantareas et al., (1978) demonstrated that teaching speech and signs simultaneously led to moderate beneficial communication outcomes for hearing children with ASD and other developmental disabilities. Bonvillian et al., (1981) meta-review of 20 studies of 100 non-verbal children with ASD aged from 3-23 years old, provided further evidence of the benefits of sign language instruction which are said to be associated with sign language instruction in ASD. Concluding, that the majority reported success in improving the communication skills of severely language disturbed children with ASD. However methodological issues weaken the conclusion, as the meta-review included studies with a lack of standardised data, individuals with ASD had different levels of language exposure prior to being taught sign language and different methodologies were employed to teach them, varying from operant conditioning to imitation and total communication. There is a lack of video evidence to date capturing individuals with ASD producing sign language this would be of significant use for analysing communicative abilities in this subgroup. However these studies are fairly dated and may have been limited by available technology at the time. It is important to know how the training was carried out in order to determine what makes it effective and replicate these findings (i.e. frequency of lessons, application to wider contexts, whether parents learnt sign language, the number of instructors that were involved, method of teaching, reward, modelling etc). The wide

variation in programs and outcomes suggests that more systematic detailed approaches are needed when assessing sign language in individuals with ASD. For example standard tests of sign language comprehension and production (e.g. the BSL Comprehension skills test (Herman et al., 1999), BSL Narrative skills test (Herman et al., 2004) or a simpler vocabulary measure (Mann 2009)) could be administered to individuals with ASD and repeated over time, with careful consideration of practice effects. Carr et al., (1978, p489) stated that “in the rush of enthusiasm to teach autistic children to use sign language, little attention has been paid to questions of experimental control.” In another meta-review Carr et al., (1987) specifically focused on the complexity of sign language that can be acquired by low functioning children with ASD. They reviewed seven studies of 52 hearing mute children with ASD who had been taught sign language. Findings demonstrated only very simple acquisition limited to nouns, which mainly enabled individuals with ASD to label food, toys and objects when requesting them. It is currently unknown what the uppermost level for sign acquisition is in an individual with ASD. There is some evidence that children with ASD can be taught generalised descriptive sentences in sign language (Carr et al., 1987). This suggests that the upper limit of sign language acquisition may be higher than the production and comprehension of single vocabulary items, particularly for high functioning individuals with ASD.

One interesting case study documented BSL acquisition in a high functioning polyglot savant (Morgan et al., 2002). “Christopher” had already learnt more than 20 spoken languages and had remarkable language learning skills but showed marked deficits in his cognitive functioning. After 8 months instruction in BSL totalling 24 hours of BSL teaching, Christopher had an impressive vocabulary and acquired BSL structures at a

comparable rate to the control group. However he showed an interesting dissociation with normal performance on some aspects of BSL (i.e. he was able to construct simple sentences involving grammatical BSL constructions for negation and question formation), yet poor performance with modality specific elements of sign language (e.g. with facial actions). There is some evidence that Christopher had difficulty with recognising faces, he was given the Warrington faces and words recognition test (Warrington, 1984). He performed within normal limits for words but he had a score of 32/50 for faces, which was too low to be given a percentile. This study differed compared to other interventions with hearing individuals with ASD, as it specifically looked at Christopher's acquisition of BSL structures. These findings are novel in two ways: firstly they demonstrate how an individual with ASD fares when learning BSL alongside healthy adult learners; and secondly progress was assessed using objective measures of BSL proficiency. It is important to note that Christopher's language as a savant would be expected to outperform learners with classic cases of ASD. However it is not known how high functioning deaf individuals with ASD would compare when learning BSL as a first language. There is a dearth of research profiling the signing abilities of this group.

In summary teaching sign language to hearing individuals with ASD can lead to some improvements in language acquisition and social behaviour, however the extent of these improvements are not adequately quantified. These findings are interesting, when compared to the case studies of deaf individuals with ASD, because a much bleaker picture is painted for deaf individuals. This suggests that there is a need for more systematic research on sign language use in deaf individuals with ASD. More specific research questions need to be asked, for example are deaf individuals with ASD impaired when

using facial actions in BSL? This outcome may be expected from the impairment with faces that is seen in hearing individuals with ASD. The face is a key structure in the grammar of sign language so it would be of interest to explore how deaf individuals with ASD fare with a specific aspect of their communication using detailed video measures.

This review has demonstrated major gaps in previous research on deafness and autism (e.g. use of low functioning individuals, subjective measures, lack of video recording and lack of group matching). Throughout this thesis these previous shortcomings will be addressed, high functioning deaf individuals with ASD will be recruited, they will be suitably matched with deaf controls and both groups will be video-recorded whilst they are given a number of objective tasks measuring facial expression production and comprehension.

Recent research on deafness and ASD

Studies comparing deaf and hearing children with ASD

Hindley (2000, p42) (a psychiatrist specialising in deaf children) stated that as a group, deaf individuals with ASD show many behavioural similarities to their hearing counterparts, with social difficulties and a lack of interest in others, delayed development of play, ritualistic behaviour and comparable cross modal language difficulties (i.e. difficulties in spoken languages in ASD are also seen in sign language). Boucher (2003, p248) stated that in ASD “language impairment is not confined to difficulty in acquiring spoken language; ability to acquire sign language is also equally affected”. Collins et al., (2007) found evidence of grammatical differences, pronoun reversal and repetition in the sign production of deaf individuals with ASD. They suggested that language specific differences are present in signing, just as they are in speech for individuals with ASD.

In existing studies of deaf/signing individuals with ASD, there has been a lack of typically developing controls. More recent comparative studies have attempted to include control groups, matching deaf signers with typically developing controls or hearing individuals with ASD who use spoken language. Roper et al., (2003) compared a group of deaf children with ASD (9) with hearing children with ASD (6) and deaf learning disabled children (8) (all groups were matched in chronological age, mean age 17 years). Teachers were given two ASD screening measures 1) the Autism Behaviour Checklist (ABC) and 2) the Interaction Assessment (IA, Krug et al., 1980, 1993). A 12 item questionnaire was completed by parents as a measure of early development. Questionnaire items differed slightly between groups to accommodate differences in hearing or autistic status. A later age of autism diagnosis was found for the deaf individuals with ASD compared to the hearing ASD group but there were no differences in symptoms. There were no differences between the three groups in terms of the age at which parents suspected there were difficulties in development. One critique of this study is that participants were older than the top threshold for norms for the ASD screening measures.

Szymanski and Brice (2008) conducted a detailed study with 16 deaf children with ASD, aged 5:0-13:0 years old. The majority of the children had deaf parents (n=13). Parents completed 'the Autism Spectrum Disorders and Deafness Questionnaire' (ASDDQ) yielding information about autistic traits, demographics, behaviour, social skills, family and communication. Children differed in communication background. A small subset used ASL alone and a larger group relied on ASL with auxillary communication (e.g. PECS, pictures etc). A key finding was that vocabulary size (50+signs) significantly correlated with higher scores on the parental questionnaire. The authors noted that less than a third of the sample

(n=6) met diagnostic criteria for ASD using questionnaire scores. Although some traits were reported that were more consistent with an ASD profile including difficulties using facial expressions and matching facial expressions to actions. The authors suggest ASD may be manifested differently in deaf children. Parents reported traits which are not typical of ASD, such as no difficulty understanding facial expressions, no avoidance of touch or eye contact and greater social engagement than is characteristic of hearing individuals with ASD. It appears that deaf children with ASD are distinguishable from hearing children with ASD in some behaviours and characteristics. These findings suggest that a greater reliance on visual communication may act as a buffer for the deaf ASD group resulting in different manifestations of ASD characteristics.

Studies comparing deaf ASD with deaf typically developing controls

Scawin (2003) adapted the Children's Communication Checklist (CCC) (Bishop, 1998) for use with deaf children who use sign language. A group of deaf children with ASD were compared to age matched typically developing deaf controls (n=13 in each group, age range 5:0-15:0 years). Inclusion criteria required the ability to produce multi sign utterances. Seven subtests from the CCC were used to obtain a composite score for social and communication ability. There was a significant difference in parental reports of communication and social abilities between groups. The ASD group had higher mean scores for each of the seven subtests of the CCC. The checklist was effective at discriminating between deaf children with ASD from those without and revealed that the former have an atypical communication style.

Bebko and Goldstein (2008) also adapted an existing questionnaire measure for use with parents of deaf children with ASD: the modified version of the Language Proficiency

Profile (LPP-2) (Bebko & McKinnon, 1993). The LPP-2 was previously normed for both typically developing deaf children and hearing children with ASD. It is a particularly useful assessment tool for deaf children, as it is not specific to the spoken language modality and it measures children's overall language ability (i.e. across both English and sign language). Bebko and Goldstein (2008) gave LPP-2 questionnaires to parents of six deaf children with ASD who were aged from 2:5-12:0 years old. Preliminary findings indicated that deaf children with ASD were more delayed in communication than typically developing deaf children. These findings reinforce previous findings that deaf children with ASD are impaired in communication compared to deaf controls (Scawin, 2003).

Studies on sign language production in deaf individuals with ASD

Recent research studies show methodological improvements in participant recruitment and group matching and are valuable in demonstrating similarities and differences between comparison groups. One limitation of these studies is the focus on questionnaires and teacher/parental reports. There is little research which looks at the sign language abilities of deaf children with ASD using video technology and detailed coding of production and comprehension. Shield (2010) investigated sign language production in 12 deaf children with ASD who were 5:0-18:0 years old. They hypothesised that visual perspective taking impairments seen in ASD (Baron-Cohen et al., 1995) would lead to phonological errors in sign language. Specifically these errors were expected to manifest in signs which need to be rotated to be correctly produced (e.g. BOY) (see Figure 1:5). A right handed signer would have to rotate their perspective to produce the sign BOY with their right hand rather than just mirror the sign. Children were presented with a range of 24 pictures of common objects for naming: half of which were mirrored signs and half were not.



Figure 1:5: Manual sign BOY

Phonological errors were annotated, the majority were found for vocabulary items which required perspective taking (i.e. the signs that could not be mirrored). In another task Shield asked deaf children with ASD to imitate nonsense gestures. He found the same type of error in production of mirrored type gestures in deaf children with ASD when they imitated the experimenter. These findings support the hypothesis that perspective taking difficulties in ASD can have an impact on sign language production. Shield stated that perspective taking rather than ToM was responsible for these impairments in the deaf ASD group as they were seen in some children before they had acquired language relevant for ToM ability (e.g. signs like know, think, feel etc). However further research is needed to determine the causality of these impairments that are seen in the deaf ASD group. This study is useful as it highlights an area of intervention for deaf individuals with ASD and it specifically demonstrates how sign language ability can be impaired, as a direct result of impairments which are associated with ASD.

The literature review indicates that deaf and autistic populations are both complex, little is known regarding prevalence and diagnosis is fraught with difficulty, as both diagnoses of deafness and ASD can be mistaken for each other on the basis of similarities between the two conditions. There is little methodologically valid research on this

subgroup. It has been demonstrated that hearing individuals with ASD have a face processing impairment which may or may not be related to ToM impairments. The main hypothesis relating to hearing individuals with ASD and their face processing impairment is the 'lack of interest' explanation that as a result of reduced attention to the face they subsequently develop impairments in face processing tasks. For deaf signers the face is crucial for both attending to and understanding and producing grammatical structures in sign language. Therefore deaf signers attend to the face more when communicating with others. Deaf signers with ASD therefore may not show these face processing impairments as they have greater experience with the face through exposure to BSL. Existing studies on deaf signers with ASD however suggest that they have broad impairments with their communication skills using sign language (not looking at face processing per se). However these studies are fraught with methodological weaknesses. More recent studies do show methodological improvements, but they are less relevant to sign language ability and more focused on diagnostic issues. There is a lack of detailed study on the linguistic features of sign language in deaf signers with ASD.

Filling in the gaps: how does this thesis follow on from existing research?

The aims of this thesis are to look at face processing of deaf children with ASD and typically developing deaf controls. This is the first study to look at general face processing ability, comprehension and production of affective facial expressions and facially expressed linguistic structures in BSL in deaf children with ASD in systematic detail. These measures have been designed so they can be replicated: they consist of video-recorded data and have coding systems which minimise the subjectivity and lack of detail from previous studies on deaf individuals with ASD.

Chapter 2: Participant recruitment and characteristics

Recruitment

The majority of the deaf children with ASD (n=11) in this study were recruited through the NHS and already had a confirmed diagnosis of autism. All participants were diagnosed at the deaf children young people and family services (DCYPFS) (National deaf child and adolescent mental health service, NDCAMHS) in the London team at Hightrees, Springfield hospital (by a team of professionals: clinical psychologists; speech and language therapists and psychiatrists). Diagnostic procedures for autism at the clinic involved specialist assessment including: history, observation of the child in different contexts (e.g. the clinic, school and home), a play assessment and a cognitive assessment, typically the Leiter International Performance Scale-Revised (Leiter-R) (Roid et al., 1997) which is a non-verbal measure of intelligence suitable for hearing impaired, cognitively delayed children and children with ASD and the Diagnostic Interview for Social and Communication Disorders (DISCO) (Wing et al., 2002). The DISCO is a clinically validated semi-structured interview with a parent, guardian or close other who has known the child since infancy. Nine of the deaf ASD group were still on the DCYPFS records, whereas the other three were former patients who had been discharged. The other two deaf ASD individuals were recruited from deaf school and received their diagnosis through social services via a speech and language therapist.

The social responsiveness scale (SRS) (Constantino & Gruber, 2005) was used as an additional screen for social difficulties, it is a 65 item questionnaire, which is suitable for use with children from the ages of 4:0-18:0 and takes 15-20 minutes to complete. It is broken down into five subscales: social awareness, social cognition, social communication,

social motivation and autistic mannerisms. Each question is rated on a scale from 0 (never true) to 3 (almost always true). An overall single standard score is generated (T score), which reflects the severity of social deficits from nonexistent to severe (the higher the score per child, the greater the severity of social impairment). Scores can vary from 0-195 (a T score of 60 or greater is used as a cut-off point to discriminate children with and without ASD). As an additional check of the diagnostic validity of the autism group, the SRS (Constantino & Gruber, 2005) was completed by teachers of all individuals from the ASD and control groups. Two questions were removed which related to tone of voice and speech. As a precaution deaf control participants with an SRS T score greater than 15 were excluded from this study. The rationale for picking this cut-off point comes from research demonstrating that deaf children typically encounter more social difficulties than their hearing counterparts and show a higher prevalence of social difficulties (Musselman et al., 1996; Harris, 2000; Hintermair, 2007). As a result three deaf controls were excluded from the study.

The data were normally distributed, therefore statistical analysis using an independent sample t-test showed that the ASD and control groups had significantly different overall SRS scores ($t(23) = -6.344, p < .001$) (Mean: ASD: 68.3, control: 4.3), the deaf ASD group also displayed higher SRS scores on every subscale compared to deaf controls (see Figure 2:1). These results are in close alignment with Scawin (2003) and Bebko and Goldstein (2008) who both demonstrated that deaf individuals with ASD can be differentiated from deaf typically developing individuals on the basis of a social screening measure/checklist.

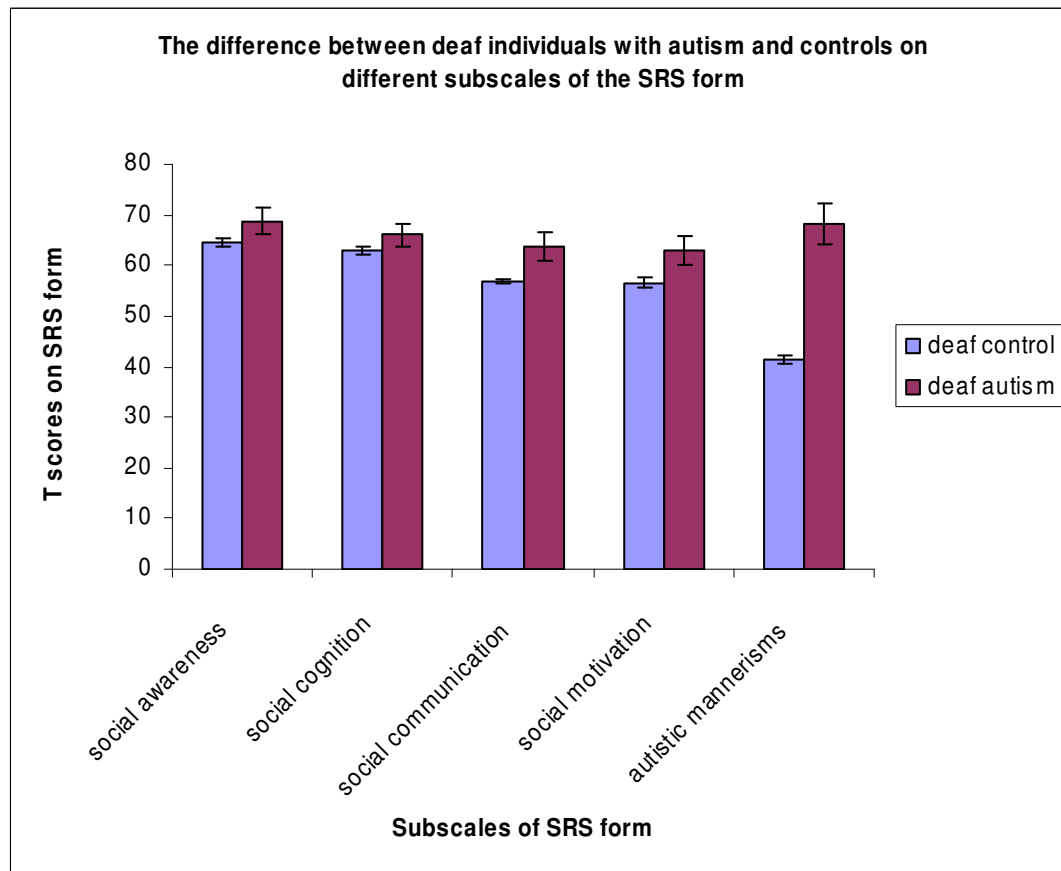


Figure 2:1: Mean scores and standard error on the SRS scale for deaf individuals with ASD and deaf controls

Ethical approval

Ethical approval was obtained from both the ethics committee at University College London and the National Research Ethics Service (NRES), which is the ethical body for the NHS. The latter also involved seeking local research and development approval from St George's hospital in London. An interview with the ethics board preceded full approval. Additional annual updates were required by NRES. The principal investigator was given an honorary research contract through the NHS to work at the DCYPFS.

Deaf individuals with ASD were located through clinical records held at the DCYPFS. A letter was then sent to parents of deaf individuals with ASD along with the project information sheet and consent form. For deaf controls, this information was sent to schools and colleges who in turn sent it out to parents. Full parental consent was obtained prior to the study. Once parents of the deaf ASD group had consented, schools and colleges of the individuals in this group were contacted to arrange for meeting and testing to take place there. Participants themselves were given full information about the tasks in BSL, they were informed that they could withdraw from the study at any time.

Participant characteristics: ASD and control groups

The deaf ASD group (n=13) consisted of three girls and 10 boys, the deaf control group (n=12) had five girls and seven boys. The presence of females in the ASD group is notable as often research studies on ASD are focused entirely on males leading to possible gender bias. “The lack of studies investigating females with autism spectrum conditions calls for a thorough investigation of their profile” (Golan et al., 2009, p178). The ASD group was made up of two individuals with a diagnosis of Asperger’s syndrome, two with diagnoses of atypical autism, and the remaining nine had diagnoses of childhood autism. Across both groups all participants had bilateral severe-profound sensori-neural hearing loss. Use of amplification was similar across both groups (ASD group: cochlear implant (7), hearing aids (4) and unaided (1); control group: cochlear implant (4), hearing aids (5) and unaided (3)).

In order to meet the inclusion criteria for the study, participants needed to be able to communicate using sign language at least at a phrasal level. Five deaf individuals with ASD were excluded due to insufficient signing skills or low levels of communicative

function. The majority of participants in both groups were non-native signers and had hearing parents, however one child in each group was a native signer. The native signing deaf control was specifically recruited to ensure participant groups were matched, as there was one deaf native signer with ASD. All participants were in bilingual education environments and were exposed to BSL in the classroom, at time of testing which ensured greater consistency in signing abilities.

Participant Matching

Participant groups were matched for: 1) Chronological age, 2) Non-verbal intellectual ability and 3) Language ability (including BSL comprehension and production). This is the first study to attempt complex multivariate matching between deaf children with ASD and deaf typically developing controls (see Table 2:1).

Chronological age

The deaf children with ASD were matched to typically developing control children in chronological age (months) ($t(23) = 2.62, p > .05$). Ages of both groups ranged from 8:5-18:0 years old (see Table 2:1 for mean group ages).

Non-verbal ability

Individuals were given the Ravens Standard Progressive Matrices (RSPM) (Raven et al., 1988), which is deemed suitable for both deaf individuals (Blennerhassett et al., 1994; Weichbold & Herka, 2003) and individuals with ASD (Dawson et al., 2007) because it is a measure of non-verbal ability with straight forward instructions, consisting of a series of diagrams, with a part missing. Participants select the correct part from a number of options underneath to complete the diagram. The RSPM has many advantages, it can be used to

compare wide age ranges and it can be administered in a short space of time (Raven et al., 1988). Raw scores were used to compare groups, as a number of studies using similar group matching procedures also used raw score for individuals with ASD, (De Gelder et al., 1991; Toichi & Kamio, 2001; Pellicano et al., 2007; Plaisted & Davis, 2009). There were no significant differences between both groups for RSPM scores ($t(22) = -2.77, p > .05$) (see Table 2:1 below).

	Mean age (y: m)	Mean age (m)	Mean BSLRST score	Mean BSLNST grammar percentile	Mean BSLNST narrative content percentile	Mean BSLNST Narrative structure	Mean RSPM raw score	Mean SRS score
Deaf ASD n=13	12:6	158	94.8	36.4	16.4	46.4	29.5	68.3
Deaf control n=12	11:8	147	95.4	37.2	25.9	52.7	28.4	4.83

Table 2:1: Matching of participant groups in chronological age, BSL ability, non-verbal ability and severity of ASD

Language ability

Participant groups were matched for both BSL comprehension and production abilities using the British Sign Language Receptive Skills Test (BSLRST) (Herman et al., 1999) and the BSL narrative skills test (BSLNST) (Herman et al., 2004).

BSL comprehension

The BSLRST was given to all participants in the deaf control group (12) and all but one in the deaf ASD group (12) (one participant refused to cooperate with the task, however as he was a native signer and had deaf parents, he was still recruited in the study on the basis that he had been exposed to sufficient BSL at home and at school). The BSLRST measures

level of receptive skill for BSL syntax and morphology. It is a standardised, norm referenced test, which is designed for typically developing deaf children aged 3:0-11:0. It begins with a vocabulary check, where individuals are asked to name pictures of test items. The child is then presented with a video of a deaf adult signing 40 sentences in BSL. The sentences are designed to assess six grammatical features in BSL: spatial verb morphology ("BOX UNDER BED"), number/distribution ("LOTS APPLE"), negation ("CAN'T REACH"), size/shape specifiers ("CURLY HAIR"), noun/verb distinctions ("BOY DRINK"), and handling classifiers ("HOLD UMBRELLA OPEN WALK") (Sutton Spence & Woll 1999). For each sentence the child responds by selecting a picture to match the signed sentence from a choice of three or four alternatives in a picture booklet. The test takes 20-30 minutes to complete and is stopped if the child fails four consecutive items. The maximum raw score is 40. The raw score is converted to a standardized score and used to calculate the child's "signing" age. Test instructions and stimuli are presented in video format to ensure standardised administration. The BSLRST is the only standardised BSL assessment. For this reason the norms for the oldest group available (11-12 years) were used for older participants. Although, this is not ideal, there is currently no standardised assessment for BSL for older age groups and adults.

An independent samples t-test was carried out between ASD and control groups and no significant differences were found between groups for overall standardised scores on the BSLRST ($t(21) = .121, p > .05$). Figure 2:2 shows that both groups have comparable accuracy scores across different subscales of the BSLRST.

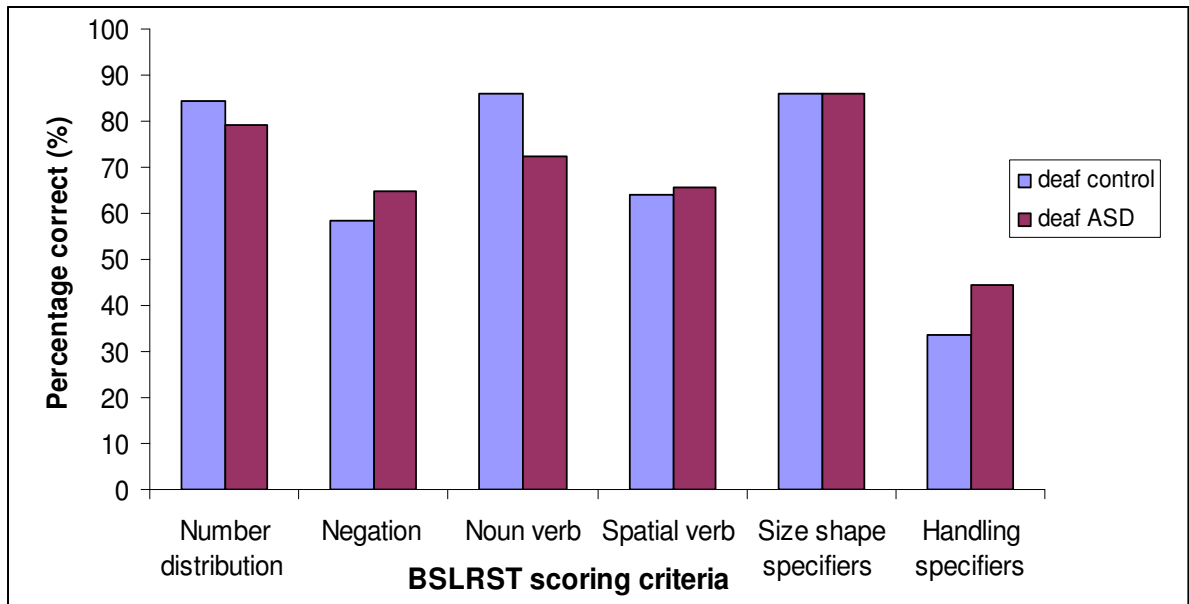


Figure 2:2: BSLRST grammatical subscale accuracy scores for both groups

BSL Narrative Skills Test: Production ability

The BSL narrative skills test (BSLNST) (Herman et al., 2004) is a standardised test of BSL productive skills (it is only normed for deaf children up to the age of 11 years, however it is often used with older deaf children). In the BSLNST children are shown a short two minute non-verbal video-clip of a dramatisation between a boy and a girl. The story involves the boy asking the girl repeatedly for her food and drink, the girl gets agitated with the boy and decides to play a trick giving him a sandwich with a spider in it. Participants were asked to watch and remember what happened in the video (they were given an option to watch the video a second time) and then describe what happened to the experimenter. Once they had finished describing the story they were shown three questions at the end of the video.

The BSLNST was given to all participants, all individuals in the deaf control group and only 10 of the 13 deaf ASD individuals were able to produce scoreable narratives using the

scoresheet that accompanies the test (these three individuals were lower in functioning, and refused to produce any meaningful story in response to watching the video, however as they did the BSLRST with no difficulty, they were still recruited in the study). For those participants in the deaf ASD group who did not do the BSLRST (1) and BSLNST (3) (1 of these was the same participant that did not do the BSLRST) they were included on the basis of the experimenter observing them in the classroom and having a signed conversation with them to determine they could produce signs at the phrasal level.

BSLNST raw scores were turned into percentiles (on the basis of participants' age) for three different aspects of the assessment: narrative content, narrative structure and grammar (see Figure 2:3). There were no significant differences between percentile scores for each group on this assessment (e.g. narrative content ($t(19)=1.45$, $p>.05$), BSL narrative structure ($t(19)=.08$, $p>.05$) and grammar ($t(19)=.36$, $p>.05$). A significant correlation was found between BSLRST standardised score and the BSLNST narrative structure percentile scores ($r(22)=.62$, $p<.05$) with a higher score on the former predicting a higher percentile on the latter. There were no significant correlations between BSLRST standardised scores and narrative content or grammar.

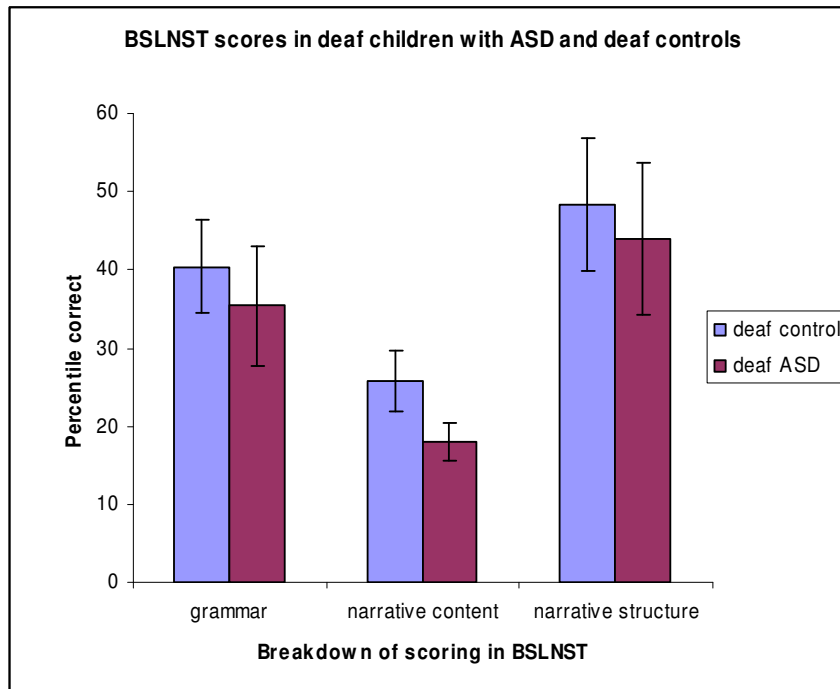


Figure 2:3: Scores on BSLNST subscales for both groups

A hearing autism matched control group was unfortunately not recruited for the purposes of this thesis. This was largely due to time restrictions and the lack of an equivalent measure across spoken and signed languages for matching groups on language ability (the BSL language measures used with the deaf groups do not have an English language equivalent). As well as the fact that the deaf ASD group were a rare and time consuming group to recruit and most time was devoted to recruitment of this group.

Procedure

All participants were tested in their school or college environment in a quiet testing room, where no other children or distractions were present (see procedure sections in each chapter for further details of testing). The room that was used for testing was often the speech and language therapy room, this ensured that the situation was less of a novel situation for

participants as they had experience of being assessed on their language using various tasks in this setting.

Chapter 3: Are deaf individuals with ASD impaired on the Benton Facial Recognition Test?

Introduction

Typically developing infants show a propensity to look at faces rather than other visual objects from 9 minutes after birth (Johnson et al., 1991), they are able to recognize faces with direct eye gaze from 4 months of age (Farroni et al., 2007) and they gradually develop an increase in attention to faces in complex dynamic scenes from 3 to 9 months (Frank et al., 2009). Various studies demonstrate that human faces due to their biological and social significance, can engage, recruit or capture attentional resources better than other objects (Lavie et al., 2003). This preference and the differences in how people process faces and objects, has led to researchers arguing that the way in which people process human faces is special (Scanlan & Johnston, 1998; Yue et al., 2006; Ro et al., 2007) However it has been demonstrated that experts can with practice process stimuli from other categories just as quickly, for example birdwatchers can categorise birds just as quickly as people can categorise faces (Grelotti et al., 2002). Ro et al., (2001) presented participants with change blindness displays (change blindness occurs when large changes are made to a flickering visual scene, which usually go undetected by viewers). The displays consisted of one unfamiliar face and five common objects. They found changes to faces were detected more rapidly and accurately than changes to objects. In a further study Ro et al., (2007) gave participants a visual search task, where they had to find one of six objects, which was surrounded by a green square and then decide if it was an exemplar of a named category (appliance, clothing, face, food, instrument or plant) and respond by saying yes or no. Findings demonstrated that faces were processed faster and they held attention for longer than the other objects. This finding was also replicated with broader category types

incorporating animal faces and inverted faces (experiment 2 &3). These findings lend further support to the hypothesis that faces have a special capacity to recruit attention when competing for attentional resources. This bias for faces may result from specific innate face-recognition mechanisms (Johnson et al., 1991) or more general preferences arising from experience with faces in development (Nelson, 2001).

Both sets of findings (i.e. that infants demonstrate preferences for faces from such an early age and that faces appear to have a special role), lead theorists to believe that there is an innately specified face module (Slater & Quinn, 2001). However an opposing view speculates that exposure to faces during early infancy is necessary for cortical pathways in the brain to become specialized for face processing expertise (Johnson et al., 1991; Nelson, 2001). Johnson et al., (1991) take a compromised view, they argued that infants have two sub-cortical systems: ‘Conspec’, an experience-independent mechanism that causes infants to preferentially attend to faces, and ‘Conlern’, a system that allows infants to receive experience with faces in the environment and enables them to develop into competent face processors. Nelson (2001) describes the transition from ‘Conspec’ to ‘Conlern’ with his experience expectant model of visual development, where exposure to faces during early development leads to perceptual and cortical specialization. If individuals do not receive this exposure to faces or the neural system is damaged then the development of a specialized face processing system may not occur.

In keeping with the argument that exposure to faces is important for face processing expertise, Frank et al., (2009) demonstrated that infants’ face specialization becomes specific to those faces they see the most, at 9 months of age infants pay less attention to faces of other races due to a lack of exposure to them. Pascalis, de Haan and Nelson, (2002)

conducted a face processing study on the discrimination of human and monkey faces with 6 and 9 month old infants. Infants at 9 months could not discriminate between monkey faces, where 6 month old infants could. In a follow up study they found that infants at 9 months old, who were given repeated exposure to the monkey faces, later maintained this discrimination ability for monkey faces. Mondloch et al., (2002) also suggested that early visual experience is necessary for specialised configural processing of faces, in their study on the face processing abilities of intact and neurologically impaired adults. Mondloch et al., (2002) investigated face processing ability in a group who had dense cataracts as babies. They were deprived of early visual input during the first 2-6 months of life and were later found to have deficits with perceiving the spatial configurations of faces as adults compared to typically developing controls. Le Grand et al., (2001) produced a similar finding, using a composite face task to compare processing in visually normal participants and the same early deprived group (Mondloch et al., 2002). Participants had to indicate whether the top halves of two faces were the same or different. Visually normal participants showed the expected composite face effect. They found it difficult to recognize a person's identity from the top half of a face when it had been aligned with a bottom half of a different face. This effect is a common result of holistic processing. Visually deprived patients did not show this composite effect, they were able to identify whether top halves of faces were the same or different even when faces were aligned or misaligned, demonstrating a lack of holistic processing of faces. This finding can be explained by their absence of early visual experience, which causes an impairment in holistic processing. The findings from these experiments strengthen the hypothesis that states that early exposure to faces is important for the development of normal face processing.

Face processing and ASD

The research in this chapter focuses on face processing in children with ASD who are also deaf. Previous research suggests that hearing children with ASD show face processing impairment relative to typically developing controls (Klin et al., 1999; Schultz et al., 2003; Dawson, 2005) (see chapter 1 for further details). If environmental experience (Nelson, 2001) is the key to the development of face processing expertise, as several studies have demonstrated (Le Grand et al., 2001; Pascalis et al., 2002), then one possibility is that a lack of interest or attention to faces during early development in ASD (Swettenham et al., 1998; Riby & Hancock, 2008) results in impaired development of specialised face processing mechanisms. Other explanations for the face processing impairment, may include a general perceptual style in ASD that involves a preference for feature level processing (Lahaie et al., 2006) or an innate impairment in face processing from birth (Sasson, 2006). However the importance of the relationship between early attention to faces and face processing development becomes even more convincing when we consider data from typically developing deaf children. Early communication and language (e.g. BSL) in deaf children relies very much on the ability to attend to faces, meaning that this group need to attend to faces more than hearing children do. Interestingly some experimental data suggests that some aspects of face processing are superior in deaf children when compared to hearing controls (Bellugi et al., 1990; Bettger et al., 1997). One prediction then is that deaf children with ASD may not suffer the impairment in face processing that is typical of hearing children with ASD, specifically because they attend more to faces in order to communicate using BSL.

Methodological issues

Although many studies have reported face processing impairments in ASD, others have failed to find deficits. Interpretation must proceed cautiously in terms of results of these studies. Participating samples and methodologies vary significantly (Jemel et al., 2006). Klin et al., (1999) suggested that face processing difficulties may not always translate into impaired performance on experimental tasks because some individuals with ASD may develop compensatory strategies. Adults with ASD display less severe face recognition deficits than children with ASD suggesting that alternative mechanisms develop over time, which minimise impairments.

A classic marker of face processing impairments in ASD is the Benton facial recognition test (BFRT) (Benton et al., 1983). The BFRT has received a great deal of attention within the autism literature and data suggests impaired performance by individuals with ASD (Wallace et al., 2008; Annaz et al., 2009). Similar findings are reported for high functioning and Asperger's syndrome groups (White et al., 2006; Howard et al., 2000). White et al., (2006) found that people with Asperger's syndrome were impaired relative to controls on this task. Similarly Howard et al., (2000) compared individuals with ASD and controls on the BFRT and found that the former group were impaired. Many studies use normal BFRT performance as an inclusion criteria for control groups where intact face processing ability is required (Palermo & Rhodes, 2006; Adolphs et al., 2008). Annaz et al., (2009) tested low and high functioning ASD groups as part of a broader comparative study with other atypical groups including Williams Syndrome and Down Syndrome with careful participant matching for chronological age. Participant groups ranged in mean age from 7:0-9:0 years old, a subset of individuals with ASD were

significantly impaired at recognising faces relative to the other groups. Of particular interest was the finding that the severity level of the ASD diagnosis correlated with BFRT, with lower function correlating with poorer BFRT performance.

Neuro-imaging evidence also points to impaired BFRT performance in individuals with ASD. An fMRI study comparing low and high functioning groups found that behavioural scores were similar across groups but that the degree of fusiform face area activation was correlated with performance in both groups (Koshino et al., 2007). The ASD group demonstrated a positive correlation between BFRT scores and right fusiform activation, with high scores equalling greater activation in this region. The control group showed the opposite effect, with high scores leading to smaller activation. The reduced activation pattern is normally found where an individual is skilled at a task, requiring less processing effort and subsequent blood flow. These findings suggest that even when performance is broadly similar, individuals with ASD are using less efficient and anomalous processing strategies for faces. Conturo et al., (2008) compared high functioning individuals with ASD and controls on a study using MRI diffusion tensor tracking. They split high functioning ASD and control groups into low vs. high face processing ability groups according to performance on the BFRT ($<$ or $>$ 42). Results showed that the ASD group had reduced right hippocampo fusiform diffusivity relative to controls whilst engaged in the BFRT. Reduced activation also predicted low performance across both ASD and controls. Thus, higher level of diffusivity positively correlated both with efficient processing strategy and with the absence of autism.

Not all studies show evidence of reduced performance suggesting a face processing impairment. Ashwin et al., (2006) and Smalley and Asparnow (1990) found that individuals with ASD performed on a par with controls and showed no detectable impairment.

Deafness and face processing

The ability to look at and to process faces is vital to deaf people. They must fixate on the face in order for language acquisition and communication to proceed. Crucially, deaf people receive language input through the visual modality either via speech reading or sign language. Face processing is also central to sign language. Signers must rapidly identify and discriminate linguistic and affective facial expressions in sign language (Emmorey & McCullough, 2008). The face is an important articulator in sign language, in addition to the hands, eyes, torso and shoulders (Vinson et al., 2008). Agriofiotis (2006) demonstrated that expert signers look at the face during sign language more than their less skilled hearing counterparts (see chapter 1). An experience expectant model (Nelson, 2001) has been proposed stating that signers are proficient at processing faces because they look more at faces and have more exposure to facial expression through linguistic and affective facial expressions in sign language. Compelling evidence for this model comes from Bettger et al., (1997) they found that native deaf signers of American Sign Language (ASL) significantly outperform hearing non-signers on the BFRT. In a further study Bettger et al., (1997) presented deaf and hearing children and adults with a version of the BFRT with inverted faces, deaf signers (both children and adults) did not differ in performance with inverted faces compared to hearing children and adults, but were better at recognising the upright faces. These findings further demonstrate that experience with sign language does not merely improve discrimination abilities overall, rather it leads to an improvement with

the processing of upright faces. This is presumably because signers look at upright faces in sign language to a greater extent.

Bettger et al., (1997) conducted a follow up study, which showed that exposure to ASL from birth is not required for a processing advantage shown on the BFRT. Both deaf native signers and those who acquired sign language after the critical period for language (non-native signers) performed equally well but were more accurate than hearing non-signers on the BFRT. Bellugi et al., (1990) confirmed a similar face processing advantage on the BFRT in signing deaf children aged 6-9 years old. Deaf children outperformed age matched hearing non-signers at every age. Bettger (1992) also extended this finding to hearing adult signers with superior performance on the BFRT in this group relative to hearing non-signers.

Interestingly no research has compared deaf non-signers who use oral communication with age matched deaf signers. This group also relies on watching faces due to communication through lip-reading, rather than sign language use. Such a comparison would allow us to separate the advantages conferred by experiences with faces in general vs. experiences with faces in the context of sign language. However a comparison of oral deaf non-signing children with hearing children, showed no difference in their performance on any visual spatial skills tests, including the BFRT (Parasnis et al., 1996). The same study compared oral deaf adults with hearing controls and found no face processing advantage. The findings from these studies suggest that sign language use not deafness per se is an important contributor to face processing skill.

It is important to note that in the Bettger et al., (1997) paper, groups are not sufficiently matched. Five experiments are described with deaf and hearing adults and

children using the BFRT. Chronological age matching only occurs in two of these experiments (with deaf and hearing children) and none of the experiments match for non-verbal intelligence or language. Therefore other explanations may account for the deaf advantage on the BFRT (e.g. the older age group of the deaf signers, higher non-verbal ability of the deaf signers etc).

Most research studies that demonstrate face processing advantages in deaf or signing individuals tend to use the BFRT, therefore it may be the case that this face processing advantage is task specific. McCullough and Emmorey (1997) produced evidence to counter this argument, they used another face processing measure and investigated whether deaf and hearing ASL signers have a superior ability to discriminate subtle differences in facial features compared with hearing non signers. Deaf and hearing participants were presented with a target face in the centre of a computer screen and after several seconds two response faces were presented side by side, one was exactly the same as the target face, the other was the same face with one facial feature replaced. Participants had to choose which face they had previously seen. Deaf and hearing signers were found to be more accurate than hearing non signers at recognizing previously seen faces. McCullough and Emmorey proposed that this advantage is specific to recognising differences in facial features rather than a more general configural advantage with faces, as both deaf and hearing ASL signers were found to be more accurate in detecting a difference in the eyes. This advantage with the eyes is likely to be linked to sign language use, as signers have to attend to changes in eye configuration, which are important in comprehending signs. Crucially, only the deaf signers were more accurate in detecting differences in the mouth. This suggests that this advantage with the mouth may be

associated specifically with deafness due to greater attention to the mouth for lip-reading in deaf adults (Emmorey, 1998). One caveat with this set of experiments relates to how the groups were matched, as participants were only matched on chronological age.

It is of interest that some studies demonstrate an advantage of hearing signers over deaf signers on face processing ability (Kolod, 2004; Grossman & Kegl, 2007). Kolod (2004) compared deaf and hearing signers with hearing non-signers on a facial identification task where they had to recognize the identity of individuals as well as affective and linguistic facial expressions specific to sign language. These expressions were novel to the hearing non-signers, so it was expected that they would show poorer performance. Results demonstrated that hearing signers had the best identification scores across all types of task, followed by the hearing non-signers and the deaf signers who had the lowest identification scores. These findings may be accounted for by the fact that the deaf signers in this study were not exposed to sign language until they were 18 years of age, so they did not have the benefit of early experience with sign language specific facial expressions. Similarly this study lacked a measure of intelligence or language fluency for each group, in order for sufficient matching to occur. Grossman and Kegl (2007) compared deaf signers with hearing non-signers on a task where they were required to recognize and categorise dynamic linguistic facial expressions in ASL. These findings were consistent with Kolod's, the hearing non-signers were found to be more accurate in their categorizations than deaf signers, although the deaf group did have higher confidence ratings in their categorization ability. However in line with Kolod's study there was no group matching on age, language ability or intelligence.

Not all studies show enhanced face processing ability in deaf and hearing signers. Denmark et al., (2007) compared deaf and hearing children (who were matched on age and non-verbal ability using the RSPM (Raven et al., 1988)) on the ability to recognize upper and lower halves of faces on the basis of identity in a forced choice matching paradigm. No difference was found between deaf and hearing children's face recognition scores for either face half. However as this was small scale unpublished research it is not possible to draw firm conclusions from this study. McCullough and Emmorey (1997) found that ASL signers were not superior at all aspects of face processing, only one of three face processing tasks showed a significant face processing advantage for deaf and hearing signers compared to hearing non-signers. In light of some of the methodological weaknesses with earlier studies that demonstrate face processing advantages in signers (i.e. with group matching) and the presence of some research studies which do not demonstrate this face processing advantage, some caution has to be given to the hypothesis that deaf signers demonstrate superior face processing to their hearing counterparts.

In summary, the BFRT has been previously used with both ASD and deaf groups, but this is the first time it has been used with a population of deaf people with ASD. The current study compared a deaf ASD group with deaf typically developing controls (who were matched on chronological age, BSL skills and non-verbal ability) on their identification of faces in the long version of the BFRT.

Experiment 1

Hypothesis

Several factors suggest that deaf signers with ASD may have a lesser degree of impairment with faces than their hearing speaking ASD counterparts. Deaf signers with ASD are forced

to look more to the face than hearing individuals with ASD, as a result of having to use sign language to communicate, therefore they are likely to have greater visual experience of the face during development. In addition to this there are face processing advantages, which are also associated specifically with sign language use (e.g. the use of varied affective and linguistic facial expressions). Signers showed enhanced BFRT scores whilst hearing people with ASD have impaired performance. There is some evidence, albeit inconclusive that deafness also confers processing advantages. It is therefore predicted that in the deaf ASD group, the advantages bestowed by sign language exposure and possibly by deafness, may offset the impairments usually found in ASD resulting in a lesser degree of impairment or unimpaired performance relative to deaf signing controls. It is hypothesized that *the deaf ASD group will show BFRT scores that closely match those of the deaf typically developing control group.*

Autism severity was taken into account by comparing low and high functioning deaf individuals on their BFRT performance. In line with Annaz et al., (2009) findings it is expected that *low functioning individuals with ASD will be more impaired on the BFRT than high functioning individuals with ASD.*

Methodology

Participants

The deaf ASD group (n=13) and deaf control group (n=12) were matched for chronological age, BSL proficiency and non-verbal ability and the deaf ASD group were significantly different from the deaf control group in autism severity measures using the SRS (see chapter 2 for group matching characteristics).

Materials

Benton Facial Recognition test

The BFRT is a standardised measure of the ability to identify and discriminate photos of unfamiliar human faces (Benton et al., 1994). The test is comprised of three parts 1) Firstly one front view photograph is matched to six front view photographs showing both the same person and two other people 2) the front view photograph is then matched with pictures at $\frac{3}{4}$ view and side angles (see Figure 3:1) and 3) front view photographs in different lighting conditions are matched. The latter conditions (2+3) require the selection of three targets from an array of six choices.

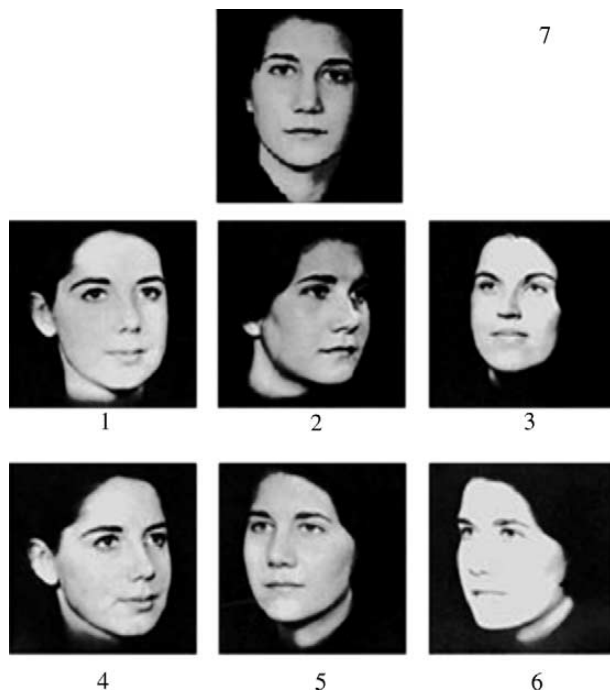


Figure 3:1: Item example from BFRT (correct targets are 2, 5 & 6)

Procedure

The original long form consisting of 54 items was completed by all participants.

Instructions were given in BSL and translated from the original English instructions. Participants were shown the test booklet and the experimenter opened the first page and instructed participants to choose the matching picture of the woman from the six pictures on the sheet below. Participants pointed out their answer and the experimenter marked correct answers and errors down on the score sheet after each response. After item six they were told they still had to match the person but the photographs were in a slightly different view (three quarter view).

Results

Scores measuring accuracy (maximum 53) were compared across groups. The deaf ASD group showed comparable performance to controls on the BFRT (see Figure 3:2) (ASD: Mean: 39.3, standard deviation (SD): 6.3, range: 31-51, control: Mean: 42.9, SD: 5.7, range: 34-53).

Scores were normally distributed, an independent t-test was calculated, no significant differences were found ($t(23) = .164, p > .05$).

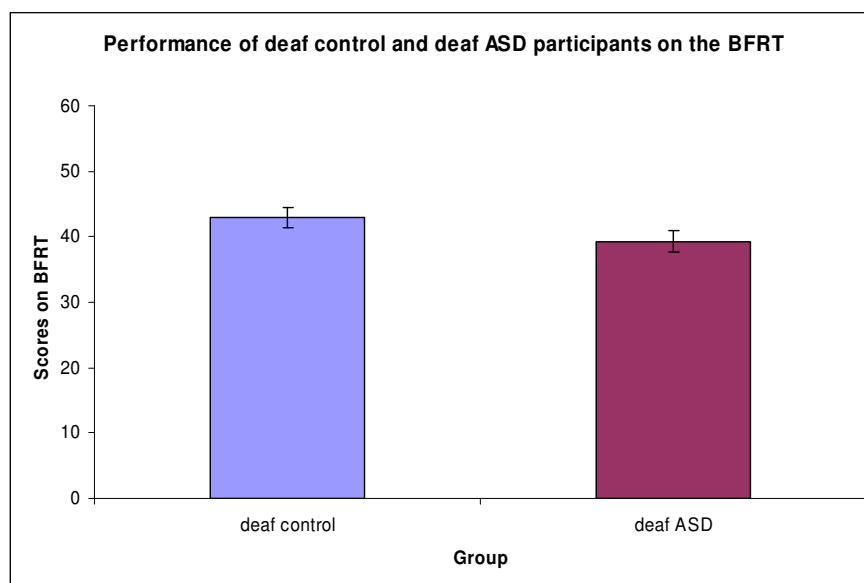


Figure 3:2: Mean accuracy scores of deaf control group and deaf ASD group on the BFRT, error bars represent standard error

Scores were divided into severity rankings as stated on the Benton score sheet according to hearing norms. BFRT classification of impairments was: normal (41-54), borderline (39-40), moderate impairment (37-38) and severe impairment (<37). The severity of participants rankings did not differ between groups ($t(23) = 3.79$, $p > .05$). The deaf ASD group had five participants with normal scores, three borderline and five with severe impairments. In the deaf control group six participants had normal scores, three had borderline scores, two were moderately impaired and one participant was severely impaired. The range is similar but the ASD group had more participants at the severe end of the continuum.

To determine whether autism severity within the deaf ASD group had an impact on BFRT scores the ASD group was split into a low functioning group (LFA) ($n=6$) and a high functioning group (HFA) ($n=7$) on the basis of their scores on the SRS. Participants with scores above and below 60 were assigned to the HFA and LFA groups respectively. There were no significant differences between autism severity (as measured by autism function) and on BFRT scores ($t(11) = .165$, $p > .05$, HFA: Mean: 36.6, SD: 4.1, LFA: Mean: 42.5, SD: 7.5) suggesting that autism pathology does not directly impinge on ability to recognise faces in deaf signers.

Discussion

The deaf ASD group do not have a classic impairment shown by hearing individuals with ASD on the BFRT, and performance mirrors that of healthy deaf controls. The direction of these findings is in line with the original hypothesis, however the fact that ASD performance is equal to controls is surprising given that this is a robust impairment in ASD.

Tentative interpretation might suggest that protective factors are available to deaf signers, which forces attention to faces during development and so leads to normal ability to recognise faces. This might be taken as evidence for the exposure/experiential hypothesis. However interpretation must proceed cautiously due to methodological weaknesses in the current study. Only one test of face processing ability was used and the BFRT only tests face recognition ability. Participants in the ASD group may have used matching strategies in the current task. It would be preferable to give both groups some further face processing tasks, such as the Ekman emotion faces task (Ekman & Friesen, 1976) which utilise different facial skills to see if this finding is extended to other uses of the face, or configural face processing tasks which further measure face processing ability. Similarly dynamic facial tasks may be more relevant for both groups as deaf signers are used to looking more at moving than static faces when comprehending sign language. The lack of face processing impairment in the deaf ASD group could be a result of the BFRT failing to discriminate between groups as a measure of face processing for both groups. The BFRT may not be a sensitive enough task, it has been criticised for not always revealing differences between ASD and control groups and findings in the literature do not always show a consistent deficit for individuals with ASD (Ashwin et al., 2006, Smalley & Asparnow, 1990). There have been some critiques regarding the BFRT (Duchaine & Nakayama, 2004), however the justification for using this task with both groups is that it is used as a classic test of face recognition and has demonstrated differences for both deaf and ASD samples compared to controls in many experiments over time. Further face processing tasks would rule out whether or not this finding is specific to the BFRT. Another possible explanation for the

lack of significant difference between the groups on the BFRT is the small sample size in each group.

An important methodological consideration with the current study is the fact that a hearing group with ASD has not been recruited. If the deaf ASD group showed spared performance on the BFRT relative to a hearing group with ASD, this would certainly suggest a positive influence of using the face in sign language in the deaf ASD group. This would allow us to gauge the true magnitude of preserved performance in the deaf ASD group (if the hearing ASD group were found to have impaired BFRT performance). Nevertheless the current finding of no difference in the deaf ASD group relative to controls is still valuable in that it suggests this characteristic impairment associated with ASD and face processing performance in the BFRT is not present in the deaf ASD group.

An additional limitation is that although experience with faces seems critical, attention to the face demanded by the visual gestural modality is mediated by the more specific exploitation of the face by signers, most notably the use of face for linguistic and affective functions. In order to test these explanations, it would be necessary to collect additional data from oral deaf people with ASD. This group do not use sign language but must also attend intensively to the face to communicate through lip reading. If they showed comparable performance to deaf controls this would support the notion that it is exposure to faces required in the context of deafness rather than experience with sign language which is the predominant mediating factor. This subgroup would be hard to find, as there is a narrow population of deaf people with ASD, reflected by small sample size and an even smaller group are educated orally. Eye tracking studies would help determine whether despite

normal performance on BFRT atypical processing strategies are shown by deaf people with ASD, as they would pick up anomalies in gaze or attention during the task.

No support was found for the second hypothesis that autism severity influences BFRT scores, as both high and low function groups showed similar performance.

The findings from this chapter demonstrate a lack of face processing deficit in the deaf ASD group. This is the first known study to date to investigate face processing ability in a deaf ASD group. A number of questions emerge from these findings: If the deaf ASD group do not show deficits in recognition and attention to faces from the limited exploration allowed by the BFRT, it is hypothesised that face processing within the context of sign language may be generally preserved. However it is hoped that the unique window afforded by the complex demands of face processing in sign language will allow patterns of preservation and in impairment to emerge in the deaf ASD group. The following chapters will document further the investigations exploring comprehension and production of facial expressions during sign language in various tasks. The remainder of the thesis can be split into two parts: 1) The investigation of affective facial expressions in sign language including the ability of deaf people with ASD to recognise (chapter 4) produce (chapter 5) and imitate (chapter 6) affective facial expressions. 2) The investigation of linguistic facial expressions in sign language (chapters 7-9).

Chapter 4: Are deaf individuals with ASD able to recognise affective facial expressions in BSL in masked and unmasked conditions?

Introduction

Chapter 3 demonstrated that the deaf ASD group do not show face processing impairments relative to a deaf control group on the Benton Facial Recognition Test. One drawback is that this task is not ecologically valid due to the use of static rather than dynamic faces and a possible use of matching as a strategy. Nevertheless it confirms basic face recognition ability is spared in deaf individuals with ASD. Throughout the rest of the thesis, the experiments look at the ability to perceive and produce facial expressions in the context of BSL. This chapter focuses on emotion recognition in BSL, the advantage of this approach is that it evaluates the abilities of the children in the context of their everyday communicative skills.

In both signed and spoken languages the ability to understand and label emotions is fundamentally important for social and emotional development (Hosie et al., 1998). Children improve throughout childhood in their ability to comprehend affective facial expressions. Patterns of acquisition for hearing children show that labels for some affective facial expressions are acquired earlier than others. By the age of 4 years children are able to label facial displays of emotion (e.g. ‘happy’, ‘sad’ and ‘angry’) with perfect accuracy and gradually become more adept with more complex emotions (e.g. ‘fear’, ‘disgust’ or ‘surprise’) (Markham & Adams, 1992; Widen & Russell, 2003). Ekman (2003) reasoned that ‘happy’ is acquired earlier because it involves recognition of mouth movements alone, whereas affective facial expressions such as ‘fear’ are learnt later, because they require integration of information from the mouth, eyes and forehead. Another factor relating to

ease of acquisition is intensity. More intense affective facial expressions have larger movements, which may make them easier to recognize (Law Smith et al., 2010). Children become better at recognizing subtle differences between facial muscle movements over time (Rump et al., 2009). A number of authors suggest that full maturation in the ability to recognize affective facial expressions does not reach adult level until around 10 years of age (Bruce et al., 2000; Mondloch et al., 2003). This age may be an underestimation, as adolescents show difficulty with recognition of subtle affective facial expressions (e.g. 'surprise', 'disgust' etc) (Herba et al., 2006; Thomas et al., 2007).

ASD and recognition of affective facial expressions

Deficits in perception of affective facial expressions are characteristic of ASD (Capps et al., 1992; Baron-Cohen et al., 1993; Grossman & Tager Flusberg, 2008; Lacroix et al., 2009; Rump et al., 2009; Volker et al., 2009). Severity of impairment depends on many other factors including: non-verbal ability, group matching and type of task (Loveland et al., 1997). Tasks with low language demand (e.g. that require matching, sorting or same/different judgments of affective facial expressions) often fail to discriminate ASD groups from controls. However those with a greater language component, (e.g. verbally labelling affective expressions or matching to written labels) reveal greater levels of impairment in individuals with ASD when compared to controls.

Recognition of subcategories of emotion

Much affective facial expression recognition research suggests individuals with ASD are impaired at recognising some types of affective facial expression relative to others. Rump et al., (2009) provided compelling evidence for a deficit in comprehending affective facial

expressions in young individuals with ASD. They compared children with ASD and controls (aged between 5-7 years old) on the ability to recognise four emotions ('happy', 'sad', 'fearful' and 'angry') from dynamic video-clips of faces. Children with ASD had significantly lower composite scores across all four emotions. Fine grained analysis of individual emotions revealed: no difference between groups for 'sad' faces; marginal difference for 'happy' faces and significant differences for 'fearful' and 'angry' faces. This finding suggests that type of emotion is important in distinguishing between ASD and control groups with specific impairments with 'fear' and 'anger'. A number of studies demonstrate that individuals with ASD are better at recognising affective facial expressions relating to external situations (e.g. 'happy', 'sad') compared to affective facial expressions relating to internal cognition (e.g. 'surprise' or 'embarrassment') (Lacroix et al., 2009). These latter examples are more complex affective facial expressions which are said to be learned as part of the biological drive for attachment and socialization process of typically developing infants (Buck, 1988).

Surprise may be a difficult affective facial expression for individuals with ASD to recognise because knowledge of surprise requires ToM (see chapter 1 for further details). Baron-Cohen et al., (1993) compared 4 year old children with ASD, mental handicap and typically developing controls on their ability to recognise and sort 'happy', 'sad' and 'surprised' affective facial expressions. The groups did not differ for 'happy' or 'sad' faces, however the ASD group showed impairment sorting the 'surprised' faces compared to the other two groups. Error analyses demonstrated that children with ASD repeatedly mistook surprised facial expressions for happy facial expressions. These findings indicate that people with ASD have difficulty recognising specific affective facial expressions, rather

than a global deficit in recognising all emotions, as children with ASD were able to recognise simple affective facial expressions (e.g. ‘happy’ and ‘sad’) with little difficulty.

Emotions in sign language

In sign languages, manual signs are produced on the hands for emotions (e.g. HAPPY, SAD, ANGRY etc. see Figure 4:1 below) but, simultaneous affective facial expressions are compulsory (Goldstein et al., 2000). The face and hands must be congruent for the meaning to be conveyed.

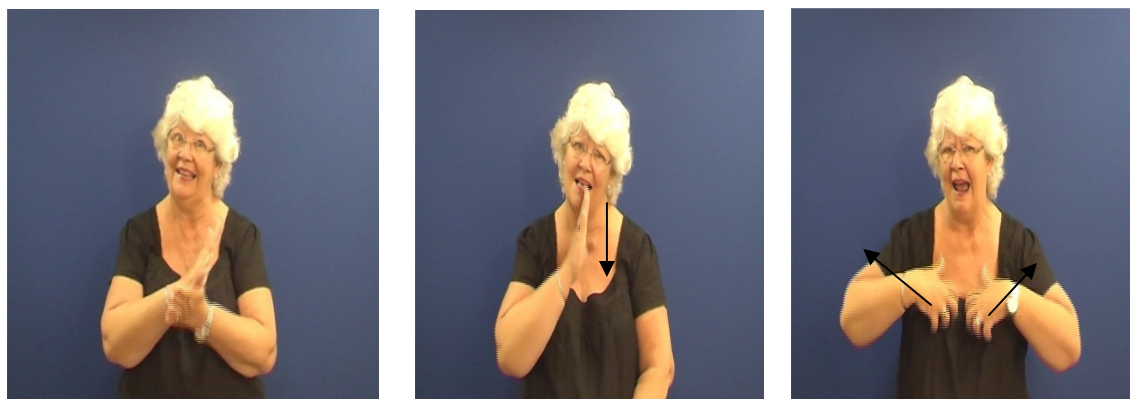


Figure 4:1: Example of emotional manual signs and facial expressions: HAPPY, SAD and ANGRY

Facial masking in deafness and ASD

The next question asked in this chapter, is the extent to which the deaf ASD group use the face and additional cues (such as manual signs and the body) in comprehending emotions in sign language. A second experimental condition with masking was developed to answer this question using an adaptation of Reilly’s experiment. Reilly et al., (1992) compared deaf adult signers on their recognition of affective facial expressions in ASL with masked and unmasked faces. A deaf signer was asked to produce the same content with five sentences, with five different affective facial expressions (‘neutral’, ‘happy’, ‘sad’, ‘angry’ and

‘surprised’). The same 25 items were then produced whilst wearing a mask, which obscured the whole face. There were 50 sentences in total: half had facial information available (unmasked) and half did not (masked). These sentences were randomised and presented to participants. Twenty-five deaf adults were asked to categorize the sentences into five different emotional states according to the original English labels. Participants responded by circling the correct written emotion label on a score sheet after they had seen each sentence. Findings demonstrated that the signers could comprehend some affective information in the masked condition (77% correct responses), but their performance improved when they could see the face (93% correct responses). This suggests that the whole face is important for revealing emotional information in sign language, but that signers are able to use other non-facial cues for emotion recognition suggesting that affective information is available on the manual articulators and body position.

Facial masking methodology is often used to explore anomalous processing strategies in ASD. Grossman and Tager Flusberg (2008) compared hearing adolescents with ASD and controls on their ability to perceive affective facial expressions when parts of the face were masked. Participants were asked to recreate the dynamic sequence of facial movements according to the start and end point of facial movement. Participants saw faces in two conditions: one where the face was displayed normally and another where the eye region was masked. Masking allowed the researchers to compare how both groups recognise affective facial expressions when some facial information was not available, forcing them to use other available cues for emotion recognition. There were two conditions: affective facial expressions and lip-read words. The control group were less accurate at sequencing affective facial expressions in the masked condition, by contrast the

ASD group showed no difference in accuracy levels for masked and unmasked stimuli. This finding suggests that the ASD group do not benefit from extra facial information conveyed through the eyes and they may use other cues in addition to the face to recognise emotions. The ASD group were found to sequence lip-read words better than affective facial expressions in both normal and masked face displays. They showed no effect of masking on lip-read words. The ASD group demonstrated a specific impairment with sequencing affective facial expressions. This latter finding provides further support for the argument that individuals with ASD are selectively impaired with recognising affective facial expressions rather than extracting linguistic information from the face. Therefore masking part of the face tells you whether that part of the face is necessary for perceiving emotion.

This chapter poses the question: if deaf individuals with ASD are presented with videos of a signer expressing emotion in BSL, do they have a spared ability to recognize emotions from the face, or does the impairment in emotion processing in hearing individuals with ASD extend to the deaf ASD group meaning they will show deficits compared to controls? Findings from chapter 3 demonstrate that the deaf ASD group do not differ from deaf controls in their ability to recognise faces. It is unknown how the deaf ASD group will fare with recognising facial expressions which convey emotion.

Current study

The deaf ASD and control groups were compared on an adaptation of Reilly et al.,’s (1992) emotion recognition test. The task was selected because it provides a measure of recognition of affective facial expressions in the context of sign language and it assesses the

extent to which judgements rely on facial or non-facial cues by manipulating facial masking.

Experiment 2

Hypotheses

1. In light of studies showing emotion recognition impairments in hearing individuals with ASD it is expected that *the deaf ASD group will be impaired relative to the deaf control group when perceiving affective facial expressions in the current task in unmasked and masked conditions.*
2. *Participants in both groups will show better performance in the unmasked condition, masking of faces will be less detrimental to the ASD group due to a lesser reliance on the face because of weaker face processing skills in this group (this hypothesis is inconsistent with findings from experiment 1 but consistent with literature on hearing individuals with ASD regarding faces and masking, Grossman & Tager Flusberg, 2008).*

Methodology

Participants

Deaf ASD group (n=13) and deaf controls (n=12) were tested (see chapter 2 for group matching characteristics).

Test Development

Eight neutral BSL sentences were filmed, five were translated to BSL from Reilly et al.,’s (1992) ASL stimuli and three additional sentences were created (see Table 4:1). Each sentence was signed to convey the same five emotional states that were used by Reilly et

al., ('happy', 'sad', 'neutral', 'surprise' and 'angry') three additional emotional states ('annoyed', 'disgust' and 'mischief') (see Figures 4:2-4:8) were added in order to determine whether more complex emotions are more problematic for deaf individuals with ASD compared with deaf controls.

Example sentences BSL: English	
1	NEXT WEEK POINT SELF BROTHER COME VISIT: Next week my brother is coming to visit
2.	DOCTOR NO GIVE MEDICINE: The doctor didn't give me any medicine
3.	FRIEND POINT FOUND DOG WANDER: My friend found her dog wandering.
4.	POINT SELF MUM GO SHOPPING: My mother has gone shopping
5.	GIRL POINT LOOK CAT: The girl is looking for her cat
6.	ME ALWAYS EAT MCDONALDS: I always eat McDonalds
7.	MUM GIVE NO MONEY: My mum didn't give me any money
8.	WE EAT SALAD LUNCH: We ate salad for lunch

Table 4:1: Example sentences used in experiment 2



Figure 4:2: Angry



Figure 4:3: Annoyed



Figure 4:4: Disgust



Figure 4:5: Happy



Figure 4:6: Mischief



Figure 4:7: Neutral



Figure 4:8: Happy masked

In contrast to Reilly's methodology digital masking was used instead of giving the signer a mask to wear, "Final cut pro" (Apple Inc) was used to mask half of the sentences. Digital masking was preferable as identical sentences were seen in masked and unmasked conditions. Physical masking would involve repetition of stimuli and may introduce subtle differences in sentence length and may have encouraged the signer to introduce compensatory movements or strategies to increase clarity when the face was obscured.

Materials

Forty-eight test items were made up of six sentences in each emotion category ('happy', 'sad', 'neutral', 'angry', 'annoyed', 'disgust', 'surprised' and 'mischief'). Because participants in the current study were children, there were fewer items compared to Reilly's experiment in order to keep their concentration on the task. Two practice items were administered to ensure understanding.

Procedure

Participants were asked if they knew the meaning of eight emotion labels presented on the scoresheet in written English, where there was uncertainty, the experimenter defined each

word using the BSL sign for the emotion and explained its meaning. All participants (whether they knew the emotion or not) were shown an example video-clip of each emotion type in the unmasked condition and they were given the written label for each emotion. This was also reinforced using BSL. Participants viewed each video-clip and were instructed to respond as quickly as they could by circling the corresponding written emotion on the scoresheet (see Appendix 1 for scoresheet). Conditions were counterbalanced, so half the participants received order A and the second half received order B. Masked and unmasked items were mixed during presentation and lists were organised so that masked or unmasked items and the same emotion type did not occur more than twice in a row.

Results

Emotion recognition scores were compared for both groups, deaf controls had higher mean accuracy scores than the deaf ASD group for both masked (ASD: Mean: 17.6, SD: 10.6, control: Mean: 22.9, SD: 9.6) and unmasked conditions (ASD: Mean: 26.9, SD: 13.1, control: Mean: 46.7, SD: 12.1) (See Figure 4:9).

The distribution of scores for both groups was normal for both masked and unmasked conditions, therefore parametric tests were used to identify group differences. Within each group a separate paired samples t-test was carried out, to determine if their accuracy for masked and unmasked conditions were similar. Both groups showed significant differences with higher accuracy scores in the unmasked condition (ASD: $t(13)=-.27$, $p<.05$, control: $t(12)=-5.8$, $p<.001$), however from looking at Figure 4:9, this difference was more pronounced for the deaf control group.

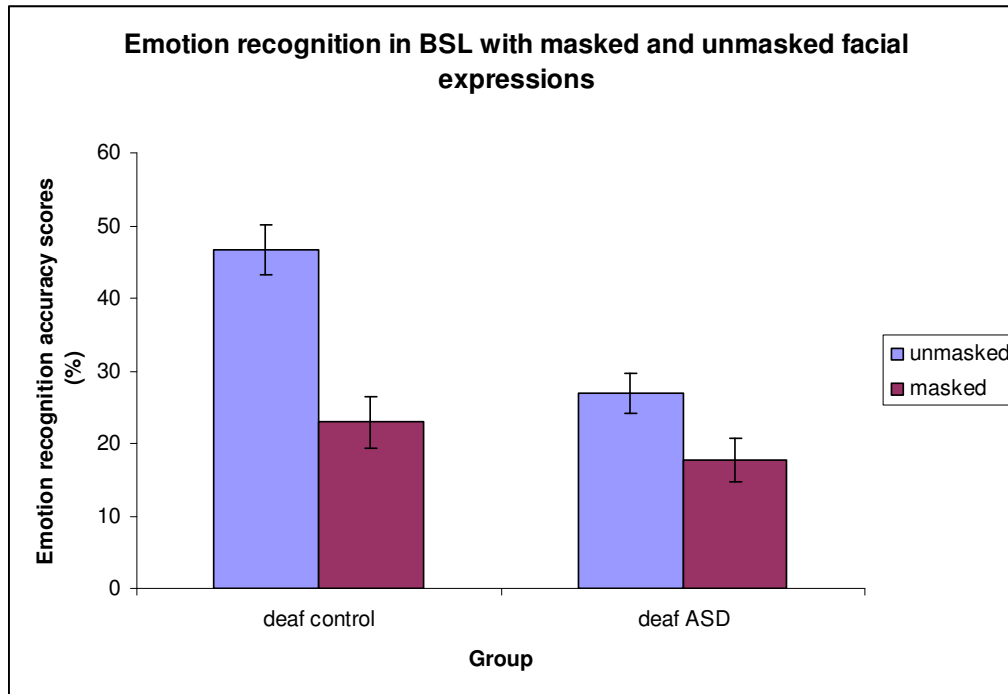


Figure 4:9: Mean accuracy scores for masked and unmasked conditions (error bars represent standard error)

An independent samples t-test was carried out comparing groups for accuracy scores across masked and unmasked conditions. Groups did not differ on emotion recognition in the masked condition ($t(23)=.017$, $p>.05$), however there was a significant difference in accuracy on the unmasked condition ($t(23)=.085$, $p<.001$), with lower scores for the ASD group when the face was visible. This finding suggests that the ASD group showed less benefit from the face when it was unmasked relative to controls.

Task difficulty meant that participants in both groups had fairly low scores in both conditions, for this reason one sample t-tests were calculated for each group to rule out the possibility of chance performance levels. The t-tests were calculated on the masked and unmasked condition using a .125 significance level, which was chosen because eight

response choices were available (eight emotions) so chance level was 1 in 8, or 12.5%.

Both groups performed significantly above chance on the masked (ASD: $t(12) = 5.9$, $p < .001$, control: $t(11) = 8.2$, $p < .001$) and the unmasked condition (ASD: $t(12) = 7.3$, $p < .001$, control: $t(11) = 13.3$, $p < .001$).

Confusion matrices were calculated for each group, looking at the number of correct and percentage of incorrect responses for specific emotion types in both the masked and unmasked conditions (see Tables 4:2-4:5). This revealed trends in each group for emotion labelling and mislabelling. Based on eyeballing the data Tables 4:4 and 4:5 demonstrate that the advantage for deaf controls in the masked condition is reduced for specific emotion types (e.g. 'mischief' (unmasked 80%, masked: 18%) 'happy' (unmasked: 80%, masked: 14%) relative to the unmasked condition. Tables 4:3 and 4:5 demonstrate that deaf controls only show a greater advantage relative to the deaf ASD group with recognising emotion types in the unmasked condition.

Emotion target	Response given (correct responses in bold)									
	deaf ASD masked	Happy	Sad	Neutral	Surprise	Angry	Annoyed	Disgust	Mischief	total % errors
	Happy	10	13	18*	18	3	15*	8	15	90
	Sad	23*	18	18	0	3	15*	15*	8	82
	Neutral	17*	5	33	5	3	26*	3	8	67
	Surprise	5	16*	13*	5	15*	15*	26*	5	95
	Angry	18*	3	15*	8	33	15	3	5	67
	Annoyed	10	5	3	17*	18*	26	13*	8	74
	Disgust	16*	31*	5	10	5	23*	5	5	95
	Mischief	15*	13*	23*	8	8	10	13*	10	90

Table 4:2: Confusion matrix showing correct responses and errors made by the deaf ASD group in face masked condition, (* marks significantly different confusion patterns from chance)

Emotion target	Response given (correct responses in bold)									
	deaf ASD unmasked	Happy	Sad	Neutral	Surprise	Angry	Annoyed	Disgust	Mischief	total % errors
	Happy	54	3	0	18*	13	7	0	5	46
	Sad	3	33	26*	5	5	13*	10	5	67
	Neutral	10	35*	26	5	3	8	8	5	74
	Surprise	31*	5	10	28	3	5	8	10	72
	Angry	10	5	15*	8	31	13	8	10	69
	Annoyed	21*	5	8	5	10	28	13*	10	72
	Disgust	5	18*	8	8	5	31*	18	7	82
	Mischief	17	8	15*	21*	0	8	3	28	72

Table 4:3: Confusion matrix showing correct responses and errors for deaf ASD group in unmasked condition (* marks significantly different confusion patterns from chance)

Emotion target	Response given (correct responses in bold)									
	Deaf control masked	Happy	Sad	Neutral	Surprise	Angry	Annoyed	Disgust	Mischief	total % errors
	Happy	14	17*	11	3	13	14	14	14	86
	Sad	19*	22	31*	3	3	14*	8	0	78
	Neutral	22*	17*	36	3	3	3	5	11*	64
	Surprise	6	25*	19*	3	3	19*	17	8	97
	Angry	6	11	3	7	47	17*	6	3	53
	Annoyed	7	11*	3	6	28*	22	17*	6	78
	Disgust	14*	33*	11*	0	11*	19*	6	6	94
	Mischief	22*	14*	8	8	11	8	11	18	82

Table 4:4 Confusion matrix showing correct responses and errors for deaf controls in face masked condition (* marks significantly different confusion patterns from chance)

Emotion target	Response given (correct responses in bold)									
	Deaf control unmasked	Happy	Sad	Neutral	Surprise	Angry	Annoyed	Disgust	Mischief	total % errors
	Happy	80	0	3	17	0	0	0	0	20
	Sad	0	47	22*	6	6	8	8	3	53
	Neutral	9	47*	33	0	0	3	0	8	67
	Surprise	34*	8	14*	19	0	8	3	14*	81
	Angry	3	8	6	0	69	11	3	0	31
	Annoyed	11*	14*	6	6	8	33	14*	8	67
	Disgust	0	19*	3	8	9	33*	14	14*	86
	Mischief	17*	8	0	6	0	0	0	69	31

Table 4:5 Confusion matrix showing correct responses and errors for deaf controls in unmasked condition (* marks significantly different confusion patterns from chance)

Both groups had the same overall error pattern for different emotion types in masked and unmasked conditions with the highest number of errors occurring for ‘disgust’, ‘surprise’ and ‘mischief’ and fewest errors for ‘happy’, ‘sad’, ‘annoyed’, ‘neutral’ and ‘angry’. The confusion matrices demonstrate several common confusion errors that occurred with labelling emotions in both groups, ‘sad’ was often mislabelled as ‘neutral’

and vice versa, 'annoyed' and 'disgust' were confused with 'angry', 'disgust' was confused with 'annoyed' and 'sad', and 'mischief' was confused with 'happy'. The ASD group demonstrated a non-significant trend with lower scores for each emotion type (in masked and unmasked conditions) compared to the deaf control group. There was an additional non-significant trend for both groups to make a greater number of confusions in the masked condition than the unmasked condition. Binomial tests were calculated to determine whether specific emotions are mislabelled significantly more often than chance (see Appendix 2 for the raw scores from binomial tests). This was calculated using the number of occurrences that one target emotion was mistaken for a particular distractor emotion on the confusion matrix. The total number of errors for that emotion type was compared with a significance level of 1/8 for each emotion type (e.g. if 'happy' was mislabelled as 'surprise' 34 times and there were 81 errors this would be calculated as $n=81$, $k=34$, $p=.0125$). The confusion errors that are significantly different from chance have been highlighted using an asterisk in the confusion matrices above (see Tables 4:2-4:5). Figure 4:10 illustrates the number of correct items recognised per emotion in the unmasked condition for both groups.

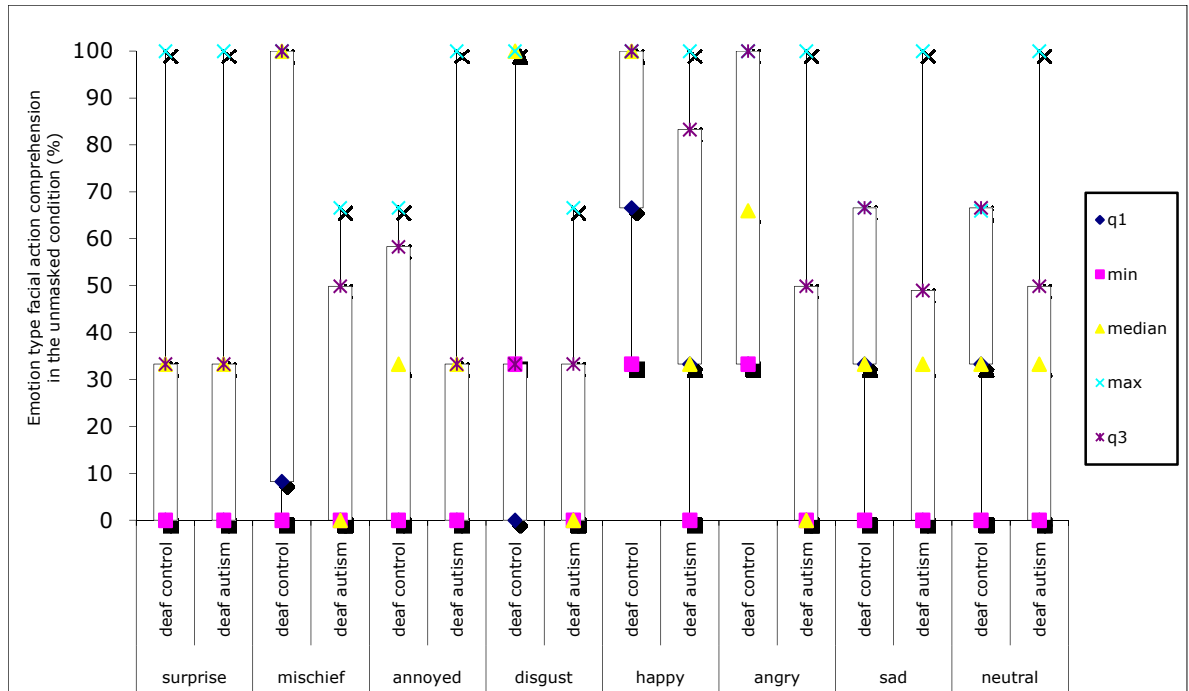


Figure 4:10: Box plot showing emotion recognition accuracy scores per emotion type in the unmasked condition, legend represents first quartile, minimum, median, maximum and third quartile values.

As the distribution across emotion types for both groups was skewed, a Mann Whitney non-parametric test was used comparing both groups on their recognition of specific affective facial expressions. A significant difference between groups was found in the unmasked condition for ‘mischief’ ($U(25)=32.5$, $p<.05$, Median: ASD: 0%, control: 100%), ‘happy’ ($U(25)=43.0$, $p<.05$, Median: ASD: 33.3%, control: 100%), and ‘angry’ ($U(25)=30.5$, $p<.05$, Median: ASD: 0%, control: 66.6%). Figure 4:10 shows that the deaf control group had higher recognition scores for these three emotions. No significant differences were found for the other five emotions. For the masked condition there were no significant differences between groups for any of the emotion types.

Complexity

Accuracy scores for recognition of complex and non-complex emotions were compared across groups. Complex emotions were categorised as 'surprised', 'mischief', 'disgust' and 'annoyed' and non-complex emotions were 'angry', 'happy', 'sad' and 'neutral' (these classifications were given on the basis of other research studies looking at complex and non-complex emotion recognition (Markham & Adams, 1992; Widen & Russell, 2004; Lacroix et al., 2009). For the unmasked condition a Mann Whitney non-parametric test demonstrated that both groups had significantly different accuracy scores for non-complex emotions ($U(25)=13.5$, $p<.001$) (Median: ASD: 33.3%, control: 58.3%) controls had significantly higher scores than the ASD group (see Figure 4:11) by contrast there was no significant group difference for complex emotions ($U(25)=49.5$, $p>.05$) (Median: ASD: 16.6%, control: 37.5%). For the masked condition there were no differences between groups for both complex ($U(25)=76$, $p>.05$) (Median: ASD: 8.3%, control: 8.3%) and non-complex emotions ($U(25)=57$, $p>.05$) (Median: ASD: 16.6%, control: 25%). In both the masked and unmasked conditions, the ASD group shows a smaller difference in accuracy between non-complex and complex emotions relative to controls, however in the masked condition the magnitude of this difference is reduced for controls. This suggests that controls utilise facial information in identifying the emotions to a greater extent than the ASD group. The implications of this finding are that the deaf ASD group do not use the face to recognise affective expressions in the same way as controls, lending support to the claim that they do manifest some face processing impairments that are seen in hearing individuals with ASD.

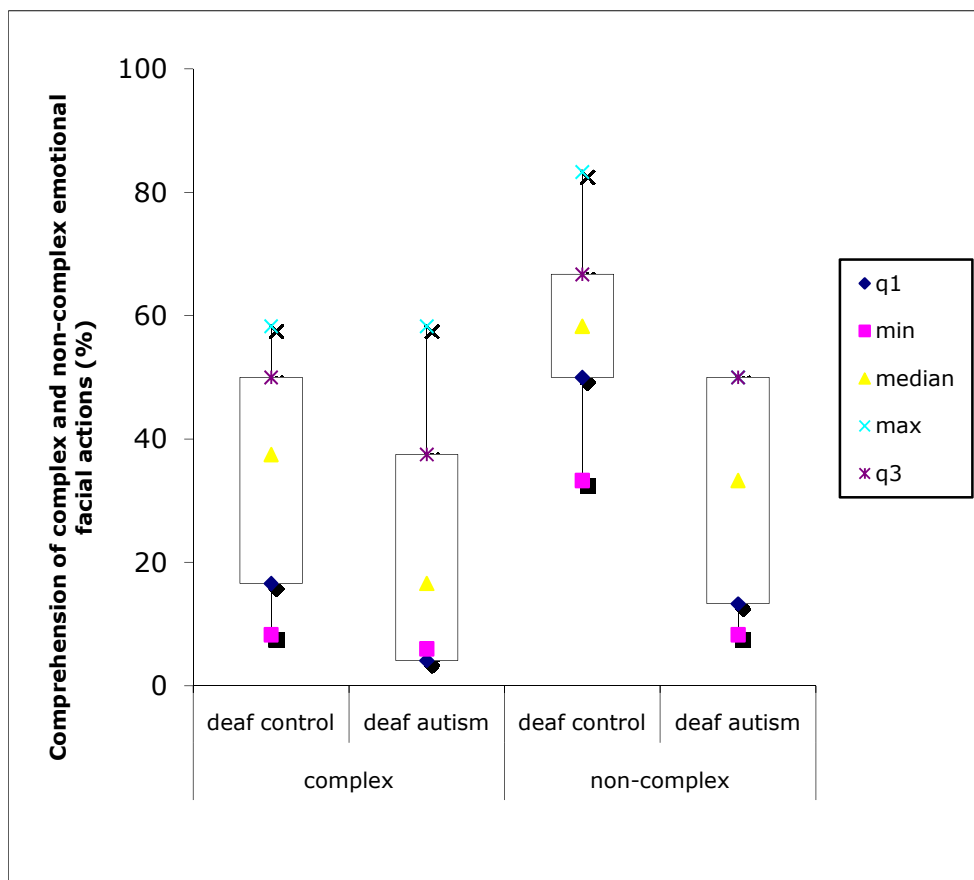


Figure 4:11: Box plot of scores for complex and non-complex emotions in the unmasked condition

Discussion

These findings are not consistent with experiment 1, which demonstrated no difference between groups for general face recognition on the BFRT. These findings partially support hypothesis (1) (that the deaf ASD group would be impaired relative to the deaf controls for both masked and unmasked conditions) demonstrating a deficit in the recognition of affective facial expressions in deaf individuals with ASD but only if the face was visible. Where the face was obscured there was no difference between groups with both groups

performing at chance levels for complex emotions. Hypothesis 2 (which stated that masking would be less detrimental to the ASD group) was supported. Both groups performed significantly better in the unmasked condition compared to the masked condition, however this difference was significantly bigger for the control group. This suggests that the integration of the face and hands has less benefit for the ASD group as they have markedly lower accuracy where both are visible compared to controls. If the face had no benefit than the deaf ASD group would have better comprehension in the masked condition, the fact that they do show some improvement in the face visible condition suggests that they do use the face to some extent for emotion recognition.

The confusion matrices revealed that both groups produced similar trends with fewer errors when recognising happy and sad faces, and more confusion errors with emotions such as surprise and disgust. In terms of complexity, on the unmasked condition the deaf ASD group had comparable performance to the deaf controls on complex emotions, however they were impaired relative to deaf controls on the non-complex emotions. These findings may have been due to floor effects where the task was too difficult, one way to test this would be to make the task easier and measure whether group differences emerge.

An important finding is that the deaf ASD group were significantly impaired relative to controls for three specific affective facial expressions in the face visible condition (e.g. 'mischief', 'happy' and 'angry'). Both groups may differ for 'happy' and 'angry' affective facial expressions, as these tend to be easier to recognise and acquired earlier in development (Widen & Russell, 2003), however this explanation does not hold for 'sadness', another specific emotion that is acquired earlier and there were no differences

between groups for 'sadness'. Whilst the explanation for group differences for 'happy' and 'angry' is unclear, the finding of an impairment with the recognition of 'mischief' in the deaf ASD group could be accounted for by ToM deficits. Mischief is more complex and needs an understanding of distinction between self and other relative to emotions such as sadness, therefore it presupposes access to other systems (e.g. ToM).

One limitation of this study is the inclusion of mischief as an emotional expression. Some research papers do refer to mischief as an emotion (Schwartz et al., 1975; Smith & Scott, 1997; Steele et al., 1999), however the majority of studies on emotional expression do not. 'Mischief' differs from the other emotions as it relates more to internal cognition. To understand mischief requires processing or a representation of what another person thinks about how you are going to behave. Deaf individuals with ASD may have difficulty understanding mischief due to an inability to make attributions about the mental state of others and their intentions. However there was no group difference for 'surprise' in the current study and the understanding of 'surprise' is also implicated with ToM ability (MacLaren & Olson, 1993). Previous research demonstrates that hearing individuals with ASD are impaired with understanding surprise (Capps et al., 1992; Baron-Cohen et al., 1993; Castelli, 2005). This absence of group difference in recognising surprise may be because children in both groups have been taught 'surprise' at school as part of emotion awareness, more complex emotions such as 'mischief' may not have been explicitly taught in the same way.

The fact that both groups were able to recognise emotions conveyed by signing even when the face is obscured lends support to the idea that other cues from the hands and body can be used to recognise affect in BSL sentences even when the face is not available.

This supports hypothesis (2) and findings parallel the findings of Reilly et al., as they found a significant main effect of facial visibility in deaf adults and that a number of emotions could be identified when the face was masked in line with the current study. One difference between these studies is the lower emotion recognition scores in the current study: (Mean: masked: ASD: 17.6%, control: 22.9% and unmasked: ASD: 26.9%, control: 46.7%) relative to Reilly's experiment: (masked 77%, unmasked 93%). These differences may have occurred between both experiments, because an additional three emotion types were added ('disgust', 'mischief' and 'annoyed') making the current task a lot more complex. Alternatively this finding could be due to sampling differences, as the current experiment looked at children's responses and Reilly's experiment was conducted with adults. Another possible difference between tasks could be related to different sign languages being used as Reilly et al.'s task involved ASL, whereas the current task used BSL, however this is unlikely.

The intention was for intensity to be consistent across the sentence stimuli, however anecdotally it was noted that (on a few of the sentences) where the emotion was signed with more intensity, individuals were able to detect the emotion label more accurately. This mirrors research findings for emotion processing in speech that show easier detection of emotions of increased intensity (Mazefsky & Oswald, 2007). The lack of control for intensity across conditions is a weakness of this study. One solution would be to obtain ratings for intensity from native deaf signers or to experimentally manipulate intensity introducing low and high intensity conditions.

A further possibility is that a general impairment with prosody might explain the findings for the ASD group. However, this explanation cannot be ruled out without giving

both groups prosodic measures. Several studies demonstrate that individuals with ASD show deficits in prosodic abilities (Tager Flusberg, 1981b; Baltaxe & Guthrie, 1987; McCann & Peppe, 2003; Peppe et al., 2006). Boucher et al., (2000) looked at emotion recognition in individuals with ASD, they reported that individuals with ASD were unable to identify emotions that were expressed vocally through intonation, yet they were able to recognise emotions that were explicit in the lexical content of sentences. It would be interesting to see if deaf individuals with ASD were still impaired with emotion recognition relative to controls in a future study, where some of the sentences in the current task had lexical emotion signs within them (ME HAPPY WE WENT MCDONALDS LUNCH) rather than being on prosodic cues alone (WE WENT MCDONALDS FOR LUNCH, with an added happy facial expression and different movement of the signs).

An alternative methodology for future studies may be fruitful, involving a comparison of attention to the hands and face in sign language when their meaning is incongruent. If deaf individuals with ASD have difficulties with affective facial processing, they may give preferential weighting to the hands in both congruent and incongruent conditions. Hietanen and Leppänen (2008) conducted an experiment of this type, non-signers were asked to make emotion judgments ('happy', 'neutral' and 'angry') from the hands and face in Finnish sign language. Static pictures of affective facial expressions in sign language were combined with dynamic videos of emotionally expressive signs using just the hands. Participants either saw faces and hands with the same affective expression in the congruent condition, or they saw faces and hands with different affective expressions in the incongruent condition. Findings demonstrated that judgments of emotion were influenced by the face when they were incongruent but only for angry and neutral affective

facial expressions. These findings suggest that some emotions capture attention better than others.

One limitation of this task is that affective facial expressions were presented within a language related task therefore it is not possible to determine whether both groups are able to recognise affective facial expressions when they are not in the context of sign language. Reduced accuracy in the deaf ASD group could to some extent come from language comprehension difficulties rather than impairments with recognising emotion from the face. Therefore it would be necessary to give both groups a face processing task which measures recognition of emotions on the face and is less dependent on language skill (e.g. Ekman & Friesen, 1976). On the other hand it would be interesting to ask both groups to give definitions of each of the emotions to see how they compare, it is possible that both groups have different knowledge about emotions that aren't conveyed through a simple recognition task. Hughes and Leekam (2004, p594) stated that “children with ASD can perceive a sad face and experience sympathy on the basis of corresponding feelings, they are incapable of inferring what the implications of this emotion would be for the other person”.

In this chapter, deaf individuals with ASD show deficits with the recognition of some affective facial expressions in the unmasked condition. These findings suggest that any advantages from increased attention to the face in sign language which are demonstrated in general face identity recognition skills in chapter 3, are not extended to emotional recognition skills in the context of BSL in deaf individuals with ASD. This is similar to Bruce's argument (1988), where the ability to recognise an expression of emotion is derived from a different perceptual system compared to the system responsible for

recognition of a person's identity. Chapter 5 explores the production of affective facial expressions in BSL. Because the findings from the current experiment hint that affective facial recognition deficits may stem from a broader ToM impairment in the deaf ASD group (with an impairment in mischief), this methodology was specifically adopted because the narrative task given to both groups also incorporated ToM skills.

Chapter 5: An analysis of emotional facial expression production in deaf individuals with ASD using the BSL Narrative Skills Test

Introduction

This chapter investigates how deaf individuals with ASD produce affective facial expressions during a narrative in BSL. Two hypotheses are prevalent in the literature relating to affective facial expression production in hearing individuals with ASD: 1) The reduced quantity hypothesis- individuals with ASD produce fewer affective facial expressions compared to typically developing controls (Yirmiya et al., 1989; Loveland et al., 1994) and 2) The reduced quality hypothesis- individuals with ASD differ in the quality of facial displays (i.e. they produce facial expressions that are perceived as odd) (MacDonald et al., 1989; Volker et al., 2009).

Support for the reduced quantity hypothesis comes from a number of studies (Yirmiya et al., 1989; Bieberich & Morgan, 1998; Muller & Schuler, 2006). Yirmiya et al., (1989) compared children with ASD and controls with mental retardation on their use of affective facial expression using the early social communication scales (ESCS) (Mundy et al., 2003). Children were observed whilst they interacted with an experimenter. Findings demonstrated that children with ASD displayed significantly less affect compared to controls. Bieberich and Morgan (1998) provided further support for the reduced quantity hypothesis in ASD, they compared children with ASD with controls with mental retardation on displays of emotion, using the Minnesota Preschool Affect Rating Scales (McPhee & Shapiro 1993). They found that children with ASD displayed more flat and neutral emotion and less positive emotion when interacting with others. Muller and Schuler

(2006) replicated this finding, using a typically developing control group, demonstrating that individuals with ASD produce more negative and less positive affective expressions.

A number of studies demonstrate that individuals with ASD produce qualitatively different facial expressions to typically developing controls in support of the reduced quality hypothesis (MacDonald et al., 1989; Volker et al., 2009). MacDonald et al., (1989) compared high functioning adults with ASD with typically developing controls on their ability to produce facial expressions for five different emotions ('happy', 'sad', 'fear', 'angry' and 'neutral') while being photographed. Judges were then asked to rate these photos using a forced choice categorical rating system, where they categorised the type of emotion and the oddity of the emotion expressed. Judges were blind to the experimental groups of participants. Results demonstrated that judges were significantly less likely to correctly identify the emotion expressed by individuals with ASD compared with controls (this was especially true for negative emotions). The affective facial expressions produced by individuals with ASD were rated as significantly odder compared to the control group. Volker et al., (2009) conducted a more recent study using a similar methodology and different sample to MacDonald's. They compared a group of 6-13 year old high functioning children with ASD with matched typically developing children on their ability to enact facial expressions for six basic emotions ('happy', 'sad', 'fear', 'angry', 'surprise' and 'disgust'). Firstly to ensure that participants understood the emotional words used and to rule out language comprehension difficulties, they were asked to pick a described emotion from a set of four pictures from the pictures of facial affect set (Ekman & Friesen, 1976). Participants in both groups were then given the experimental stimuli, they were read a statement and asked to show a targeted emotion from the statement (e.g. "I want you to

think of a time that you were really, really happy... Show me a happy face.”) Photos were then taken of the children enacting these emotions. Six judges rated the photographs of children’s enacted facial expressions in terms of accuracy and oddity, they were blind to the experimental groups. Children with ASD produced significantly fewer facial expressions and their facial expressions were rated as more unusual or odd compared to controls.

Facial expression production methodology

Most studies use non-naturalistic and controlled methods to elicit affective facial expressions. For example participants are presented with photos or video-clips of affective expressions and are asked to imitate the facial expression, alternatively participants are asked to produce a facial expression that they may make in certain scenarios (e.g. when they are feeling sad or in response to a verbal label) (MacDonald et al., 1989; Volker et al., 2009). There is a lack of research on the production of spontaneous and naturalistic facial expressions of emotion (Tcherkassof et al., 2007). This is important as Rinn (1984) demonstrated that spontaneous and controlled facial expressions result from activity in different neural pathways. Controlled movements come from the cortical motor strip through the pyramidal tract, whereas spontaneous movements come from the extrapyramidal motor system. In line with Rinn’s hypothesis, several research studies have detected differences in the timing and movement characteristics of spontaneous and deliberate facial expressions (Schmidt et al., 2006; Valstar et al., 2006).

A few different methodologies to date have been used in order to elicit spontaneous facial expressions from participants. One methodology involves filming participants covertly whilst they are presented with an emotional stimulus (Sebe et al., 2004), however this does not give rich data in terms of expressiveness. Another method involves

naturalistic observation of facial expressions that are produced during conversations with an experimenter (Zeng et al., 2006). This methodology was not used in the current experiment, due to the difficulty of ensuring that all participants produced similar content (in terms of affective facial expressions produced) during their conversations with the experimenter. The ASD group may be impaired with conversational skills relative to the control group which would disadvantage their performance. An alternative method was adopted by Hendricks (2007), a short narrative and question-answer paradigm was given to participants in order to elicit facial expressions in Jordanian sign language. Hendricks stated that a benefit of using narratives when assessing facial expression productions is that the topic, content and length of discourse can be controlled among individuals. For the purposes of the current study a similar methodology was adopted, where spontaneous facial expressions were observed using the BSL Narrative Skills Test (BSLNST).

BSL Narrative Skills Test

The BSLNST (Herman et al., 2004) is a test of sign language production that is commonly used to measure BSL skills in deaf children. For the purposes of the current experiment, the BSLNST was used as solely a measure of facial expression production. Few research studies have been conducted using the BSLNST. Cobbold (2000) compared a group of typically developing deaf children with deaf parents (native signers) and a group of typically developing deaf children with hearing parents (non-native signers) on their BSL scores that were obtained from the BSLNST (Herman et al., 2004). Children were aged between 5:0-11:0 years old. Participants were split into a young group (n=6, 5:0-6:0), a middle group (n=6, 8:0-9:0) and an older group (n=4, 9:0-11:0). Overall no significant differences in scores were found between the three groups on their narrative ability.

However it is interesting to note that of the 16 children that did the BSLNST, only 10 successfully used facial expressions in their narrative and those 10 individuals, consequently scored significantly higher on the BSLNST than those who did not use facial expressions correctly. The latter group either did not change facial expression when required by the narrative, or they had inappropriate facial expressions which did not correspond to their manual signs (e.g. they smiled instead of showing frustration).

This is the first known study to date looking at the production of facial expressions within a narrative task by signers with ASD. The type of facial expressions that were elicited by this task were opportunistic ('demand', 'refusal', 'annoyed', 'surprise', 'mischief', 'disgust') in that they were not all strictly emotional (e.g. 'demand'), however they were relevant to the story telling and emotion of the two characters and it was of interest to compare how participants produced these facial expressions. Therefore they will be referred to as affective facial expressions for the duration of the chapter. Linguistic facial expressions were not investigated in this task, as they will be investigated at a later stage in this thesis.

Experiment 3

Hypothesis

Findings from chapter 4 demonstrated that the deaf ASD group were impaired relative to the deaf control group at comprehending some affective facial expressions. In light of evidence from several studies showing that hearing individuals with ASD have reduced quantity and quality of affective facial expressions relative to controls (Yirmiya, Kasari et al., 1989; Volker, Lopata et al., 2009) two hypotheses are formulated.

1. *The deaf ASD group will produce fewer (quantity) affective facial expression targets than deaf controls during their narrative productions.*
2. *It is expected that their affective facial expressions will be of reduced quality compared to deaf controls.*

Methodology

Participants

The deaf ASD group (n=10) were compared with deaf typically developing controls (n=12) (see chapter 2 for group matching characteristics). Three individuals from the deaf ASD group did not produce narratives so were not included in this task.

Materials

The BSLNST involves watching a story on videotape and retelling it in BSL. The video features two children in a non-language behavioural interaction.

Story segment (description of part of the video content). She gets up, goes to the tray and decides to take a cake. She is about to eat it when the boy demands it and she gives it to him. The girl makes a sandwich with a spider in it, then sits down, holding the sandwich. The boy demands the sandwich, bites into it, then takes the spider out of his mouth and screams. He throws the spider at her and they chase each other around the room.

Procedure

Participants were asked to watch the video and retell the story from memory, their story production was captured on video for analysis. The experimenter left the room whilst the video played and on the experimenters return, she asked participants to retell the story as

accurately as they could. After participants retold the story, they were asked three questions to elicit their understanding of the scenario and the character's feelings.

Coding system

The two actors produced facial expressions within the video, (however these facial expressions were not produced with manual signs as there was no dialogue). Figures 5:1-5:5 demonstrate the facial expressions that were produced in the video. Table 5:1 shows the number of times each expression appears in the scenario and which actor produced them.

Example facial expressions produced by the characters



Figure 5:1: Demand



Figure 5:2: Refusal



Figure 5:3: Surprise



Figure 5:4: Mischief

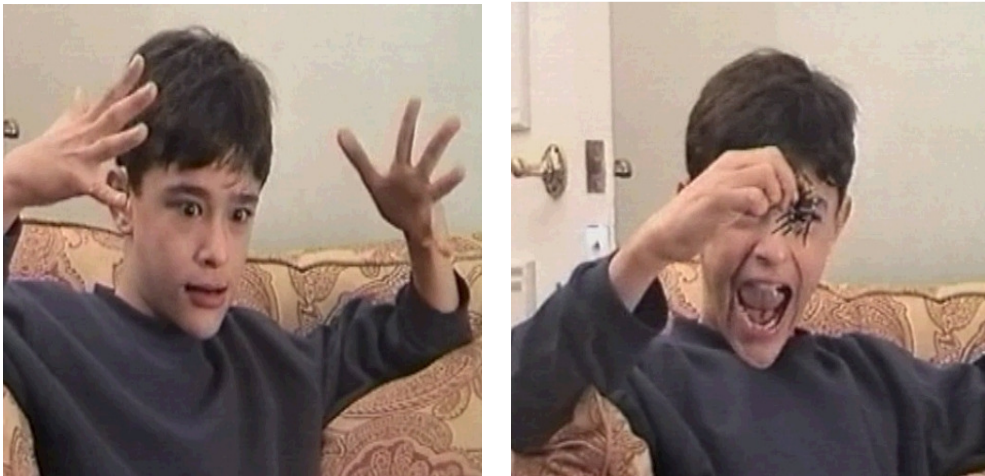


Figure 5:5: Disgust/Shock

Affective expression	Number of times produced in narrative	Character
Demand	4	boy
Refusal	4	girl
Annoyance	3	girl
Surprise	1	girl
Mischief	2	girl
Disgust	2	boy

Table 5:1: Number of affective expressions in the BSLNST

Analysis

The narratives of two deaf adult native signers were filmed and their stories were analysed using ELAN version 3.81 (EUDICO Linguistic Annotator, Max Planck Institute for Psycholinguistics). A coding system was formulated on the basis of their productions. Adult models were used rather than children to ensure that language and memory systems were fully developed. Native signers were selected because many research studies recruit deaf-of-deaf informants who have acquired sign language in the most “natural” or native-like context (McIntire and Reilly, 1988; Costello, Fernandez et al., 2006; Cormier and Smith, 2010) and therefore their productions are more likely to represent best case

examples for this task. Both signers were staff members at the Deafness Cognition and Language Research Centre (DCAL) UCL, they were male, had been signing since birth and were 25 and 40 years old.

In the coding system specific facial action targets were associated with each affective facial expression type produced by the adult models during the narrative task (see Table 5:2 below).

Affective expression	No of facial action targets
<i>Demand</i>	1) Nod head forward 2) Furrow or raise eyebrows intensely 3) Widen eyes 4) Downturned closed mouth 5) Blink slowly
<i>Refusal</i>	1) Head shake 2) Furrowed eyebrows 3) Frown 4) Wrinkled nose
<i>Annoyance</i>	1) Roll eyes 2) Raise eyebrows 3) Shrug shoulders
<i>Surprise</i>	1) Widen eyes (2) Raise eyebrows
<i>Mischief</i>	1) Look from side to side 2) Raise shoulders 3) Raise eyebrows
<i>Disgust</i>	1) Raise eyebrows 2) Widen eyes 3) Mouth wide open 4) Furrowed eyebrows 5) Tilted back, body or head

Table 5:2: Affective expressions in the BSLNST and their corresponding facial actions

The facial action targets produced are largely similar to those produced by the characters, for example for the expression of 'demand', the deaf native signer (in Figure 5:6) produces the same facial configuration as the character in addition to the manual sign for DEMAND (see Figure 5:1).

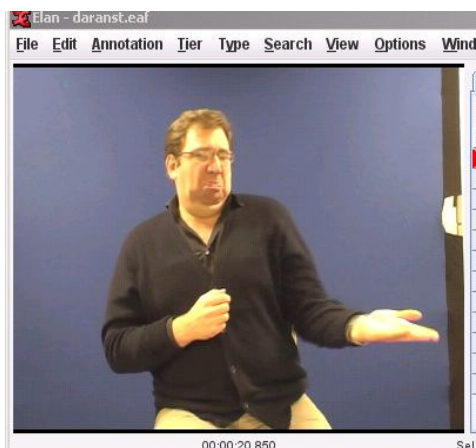


Figure 5:6: Deaf adult native signer producing facial actions for DEMAND

The video-clips of each participant's narrative production were analysed using ELAN in order to determine whether deaf children with ASD and deaf controls differed in their production of affective facial expressions. Firstly, each child's narrative was scored for quantity, to mark which affective facial expressions were used and how often each facial expression was produced relative to the number of times it appeared in the original acted scenario (see Table 5:1). Secondly, productions were coded for quality in terms of how similar the facial expressions were to those produced by the adult model signers, specifically whether these facial movements were identical, similar, blank or miscellaneous compared to the adult signers (see Figure 5:7). For example, if the child produced a facial action for an emotional target in exactly the same way as the adults, then their production was coded as identical. If they produced a facial action target that was slightly different from the adults target then it was coded as similar. If facial actions were not produced at all then they were coded as blank and if they were added, so that expressions not produced by the adult signers were present, then they were coded as miscellaneous.

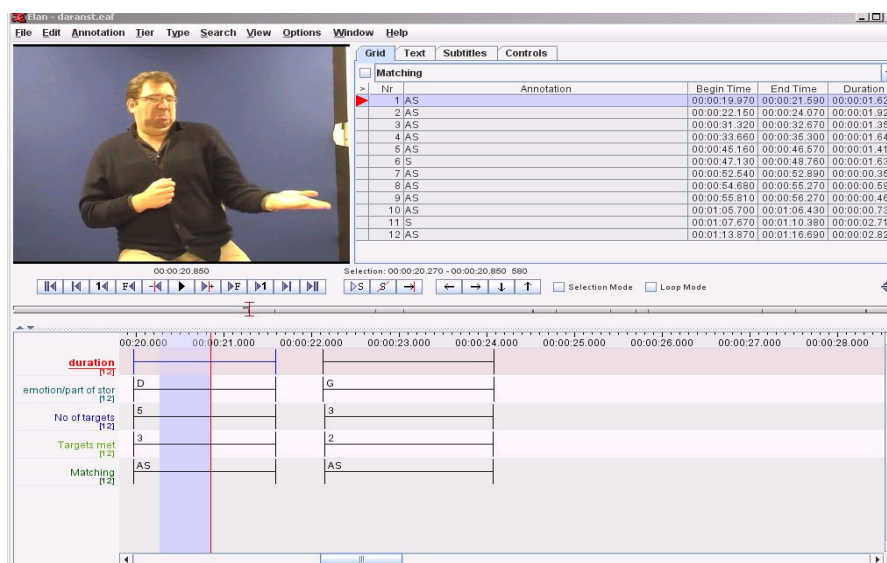


Figure 5:7: Example of deaf adult signer’s scoresheet on ELAN

Results

Each participant’s score was calculated on the basis of number of productions and how many facial actions they produced for each emotion relative to the maximum possible score for that emotion. For example one participant ‘X’ produced 3 demand facial expressions (maximum score is 5 for an expression for demand, so $3 \times 5 = 15$ for demand) participant X scored 11 out of 15 for demand, therefore he missed 4 facial actions in his productions for demand. He produced 11 emotional facial expressions in total and his overall score when all the other emotions he produced were calculated in the same way was 32 out of a maximum score of 44. Scores for each participant were then converted into percentages from their total number of facial actions (32) divided by the maximum number of facial actions that they could have produced (44). For participant ‘X’ his score for quantity of facial actions was 72%. This ensured that participants scores were comparable and accounted for participants different narrative lengths, with a differing number of emotional

descriptions and a different amount of content (e.g. some participants included all four demands from the boy to the girl in their narrative, others only included two and some participants did not mention the boys demands at all), therefore this affected how many demand facial expressions they produced. Participants in both groups were therefore compared on their number of overall facial actions produced (for all emotions combined) relative to the deaf adults. Because the distribution was not normal non-parametric statistics were chosen, a Mann Whitney test compared groups on quantity of facial actions produced, there were no significant differences between groups on total production of facial actions relative to adults ($U(25)=50$, $p>.05$), (Median: ASD: 45.7%, control: 53.9%). The ASD group showed fewer productions, although this was not significant. The deaf ASD group produced on average 10 of these key emotional states and the deaf controls produced 13 per narrative. Both groups did not differ on the duration of narratives produced ($U(25)=41$, $p>.05$).

Figure 5:8 shows a difference in the number of facial action targets produced by each group for some emotion types but not others. Notably significantly different emotions included ‘demand’ ($U(25)=29.5$, $p<.05$) and ‘mischief’ ($U(25)=35.5$, $p<.05$). There were no significant differences between groups for the other emotion types (‘annoyance’, ‘refusal’, ‘surprise’, ‘disgust’) (see Table 5:3).

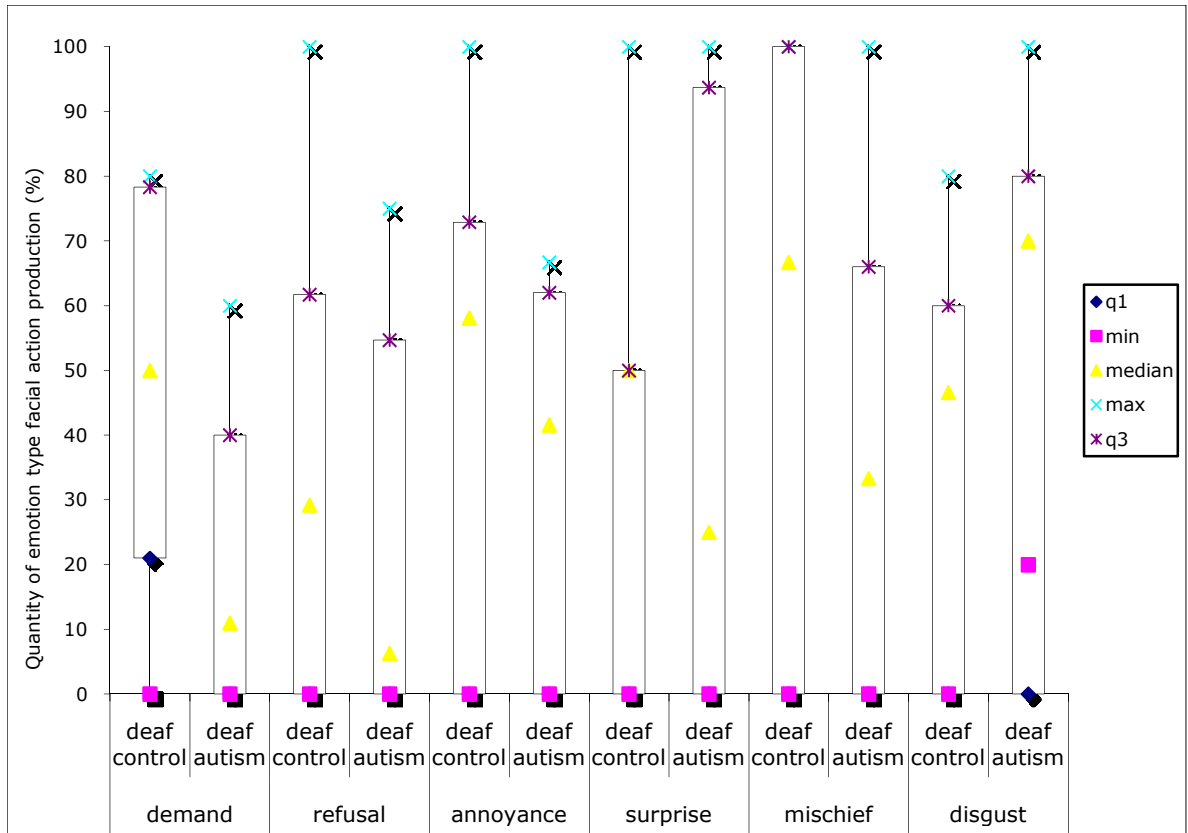


Figure 5:8: Box plot showing production of different affective facial expression types for deaf ASD and control groups

Emotion type	Deaf control Median	Deaf ASD Median
Demand	50%	11%
Annoyance	58%	42%
Mischief	67%	33%
Surprise	50%	25%
Disgust	47%	70%
Refusal	29%	6%

Table 5:3: Median facial expression target production for different emotion types for both groups

A second rater (a deaf adult native signer) coded 20 % of the BSLNST videos for quantity of facial expressions. The rater was blind to participant group (3 deaf ASD and 2 deaf controls). An intraclass correlation was carried out and overall agreement between the raters was .944.

The total number of identical, similar, miscellaneous and blank facial actions was calculated for each participant. No significant differences between groups were found in the number of blank facial expressions. For the remaining non-blank facial actions (identical, similar and miscellaneous), frequency of these three categories combined was calculated and each category was worked out as a proportion of the total expression each participant produced (e.g. if a participant had produced seven identical facial actions, three similar and two miscellaneous the total number of non-blank facial actions was 12). To calculate differences between both groups for one of these categories (e.g. identical, $n=7$) the proportion of $7/12$ the identical score/the total score for all produced facial actions (identical+similar+miscellaneous) was calculated per participant. The proportion of identical facial expressions in the narrative differed significantly between groups ($U(25) = 37.5, p < .05$), with the deaf control group producing a greater proportion of identical facial expressions in the narrative compared to the deaf ASD group (see Figure 5:9). There were no significant differences between groups for similar and miscellaneous facial expressions.

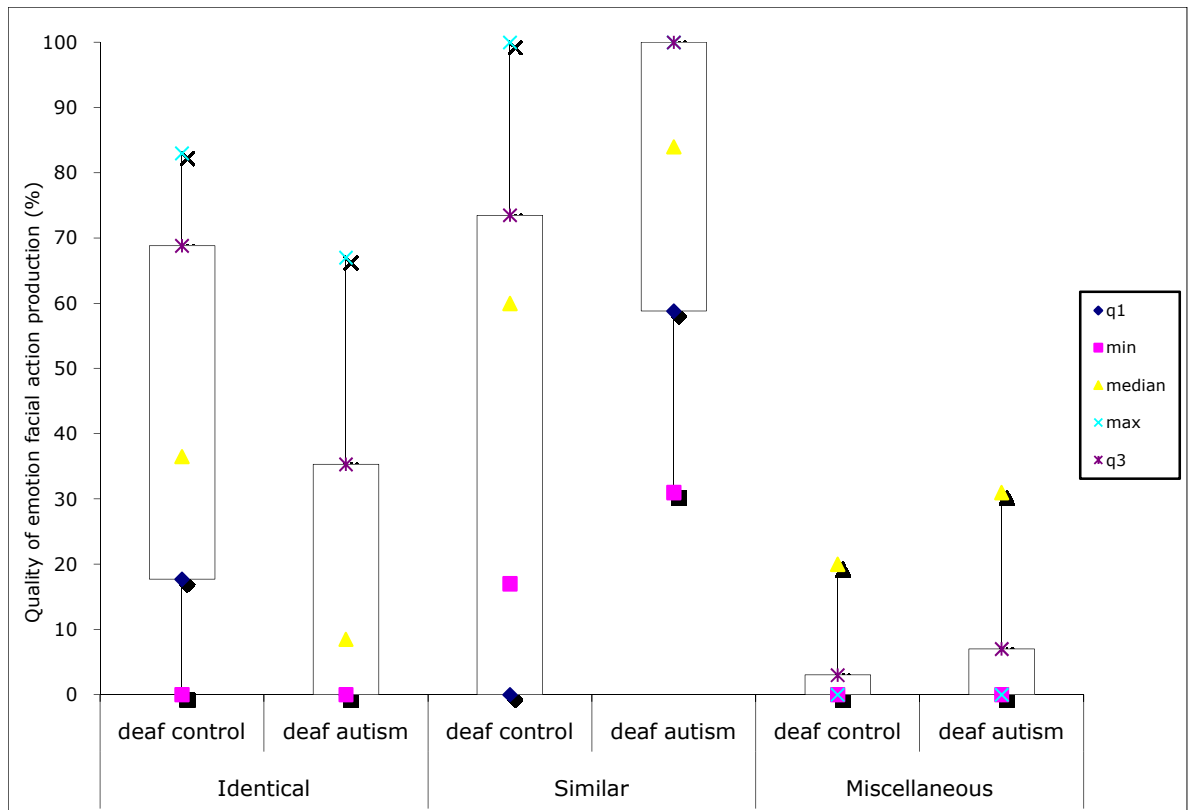


Figure 5:9: Box plot showing quality of affective facial expressions produced in the BSLNST

BSL proficiency

The narratives were scored according to the BSLNST procedure to obtain a measure of BSL production ability and confirm that participants in both groups understood the task and were comparable in their retelling ability. The BSLNST manual gives the following scoring procedure:

Narrative Content

How much information does the child provide and how do they respond to questions?
(Scored out of 22).

Narrative Structure

What is the structure of their narrative? Do they provide information regarding orientation, complicating actions, climax, resolution, evaluation and narrative sequence? (Scored out of 12).

BSL Grammar

Are aspects of BSL grammar (e.g. aspect manner, spatial verbs, agreement verbs and role-shift) produced accurately? (Scored out of 30).

Participants scores on these three parameters were marked using the BSLNST scoresheet (see Appendix 3 for example BSLNST scoresheet). Using the BSL normative data, scores were then converted into percentiles which indicate where within a normal distribution, the participant's score fell relative to typically developing deaf children the same age. These percentiles indicate what 10, 25, 50, 75 and 90% of children in each age group obtain for each structure (see Figure 5:10). One shortcoming with using this scoring method for the current sample is that the normative data for this test only goes up to the age of 11 years (ASD group: 11 and under: n=5 and older than 11: n=8, control group: 11 and under: n=7 and older than 11: n=5). Therefore, percentiles for all participants older than the 11 years were calculated at this upper age limit, so effectively they are being compared to younger children. Therefore raw scores were also compared alongside percentiles to reduce any scoring biases that may arise from the inclusion of older age groups into younger age cut-off points (see Figure 5:11).

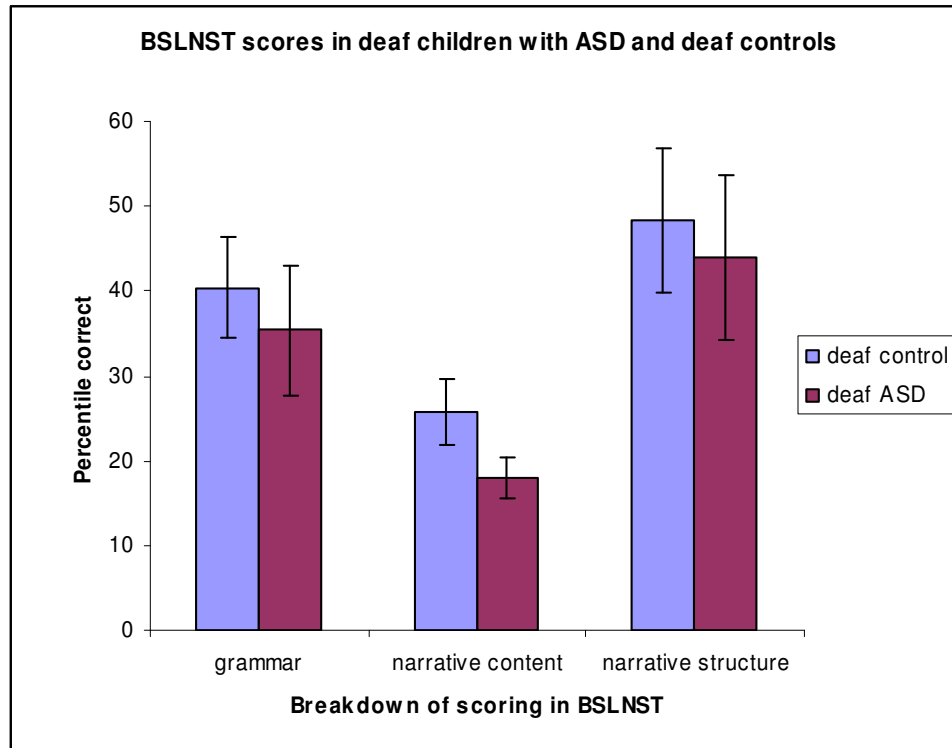


Figure 5:10: BSLNST percentiles for deaf ASD and control groups

A Kruskal-Wallis non-parametric test was calculated for both groups on each parameter using percentiles. No significant differences were found between groups for grammar ($H=.169$, $1df$, $p=.68$), narrative content ($H=2.18$, $1df$, $p=.14$) and narrative structure ($H=.005$, $1df$, $p=.94$). Figure 5:10 shows that both groups did not differ significantly on their scores on each parameter. However it is of interest that both groups have means falling below the 50th percentile for each parameter using percentiles, especially the control group, who were a high functioning group (as all participants with low language and high SRS scores were excluded). In light of these findings the decision to report raw scores for each parameter was justified to determine whether controls show similarly low scores on the test when approximate age percentiles are not given to them. A Kruskal-Wallis non-

parametric test was also calculated for raw scores on each parameter no differences were found between groups for raw scores on grammar ($H=2.132$, 1df, $p=1.44$), narrative content ($H=.132$, 1df, $p=.716$) and narrative structure ($H=.018$, 1df, $p=.893$).

BSLNST includes screening question to ensure participants' understand the scenario, three questions were asked in BSL. The translated English equivalents are: 1) what was on the tray? 2) why did the boy throw the spider? and 3) why did the girl tease the boy? Questions 2 and 3 also have a ToM component as understanding of mental states and motivation of the protagonists are required to answer correctly. Each question was worth 2 points, and there was a maximum obtainable score of 6 points. Both groups were compared on this composite score and no significant difference was found ($t(22)=-.699$, $p>.05$, Mean: ASD: 46%, control: 42%). This suggests that both groups had equivalent understanding of the narrative.

Figure 5:11: Example of deaf individual with ASD producing DEMAND with blank facial expression

Figure 5:12: Example of deaf control producing DEMAND with identical facial expression

Figure 5:13: Example of deaf individual with ASD producing DISGUST/SHOCK with similar facial expression

Figure 5:14: Example of deaf control producing DISGUST/SHOCK with identical facial expression

The still images above demonstrate that deaf individuals with ASD are capable of producing facial expressions for different emotions (e.g. see Figure 5:13 and 5:14 for similar disgusted expressions). However there are specific items for which their facial expressions did not have the same quality as deaf controls. Figure 5:11 and 5:12 comparing a deaf individual with ASD and a deaf control on the production of the sign ‘demand’ demonstrates this difference, the former failed to produce a congruent target expression in synchrony with his manual production of the sign ‘DEMAND’, instead he produces a blank facial expression (with an incongruent smile). By contrast, the deaf control participant produces all facial expression targets including: raised eyebrows, widened eyes, a tightening of the mouth and his head tilted down in a congruent facial expression.

Discussion

A reduction in quantity of affective expressions was found for the ASD group during a signed narrative, but only for two specific emotion types (e.g. ‘demand’ and ‘mischief’). This finding was somewhat in line with hypothesis 1 (which stated that the ASD group would produce fewer facial expressions than controls) however the ASD group did not show fewer facial expression targets for each emotion type. Quality also differed with the ASD group producing fewer identical facial action targets. This supported hypothesis 2 (which stated that the ASD group would produce facial expressions of reduced quality

relative to controls), however there were no significant differences between groups in the production of similar, blank and miscellaneous facial actions. The reduced quality of identical facial expression production in deaf individuals with ASD mirrors findings for hearing individuals with ASD (MacDonald et al., 1989; Volker et al., 2009).

Furthermore there is no physical explanation, relating to the muscular demands named by the facial actions for mischief and demand, which would explain specific difficulty with these two emotion types. For ‘mischief’ the raised eyebrows also occur for expressions of ‘annoyance’ and ‘surprise’, however the raised shoulders and look from side to side was unique to this emotional expression. Facial actions for ‘demand’ also feature in other emotion expressions, for example widened eyes are also present in ‘surprise’ and ‘disgust’, the eyebrows are furrowed and raised in all other emotional types and the mouth is downturned in refusal. The only unique elements for ‘demand’ are the slow blinking and the forward head nod. Arguably, complexity is not an explanation, ‘Demand’ does have several facial action targets that need to be produced (see Table 5:4), however ‘disgust’ has comparable complexity with a similar number of facial action targets and ASD participants did not find production problematic.

Affective expression	No of facial action targets
<i>Demand*</i>	1) Nod head forward, 2) Furrow or raise eyebrows intensely, 3) Widen eyes, 4) Downturned closed mouth, 5) Blink slowly
<i>Refusal</i>	1) Head shake 2) Furrowed eyebrows 3) downturned mouth/Frown 4) Wrinkled nose
<i>Annoyance</i>	1) Roll eyes 2) Raise eyebrows 3) Shrug shoulders
<i>Surprise</i>	1) Widen eyes (2) Raise eyebrows
<i>Mischief*</i>	1) Look from side to side 2) Raise shoulders 3) Raise eyebrows
<i>Disgust</i>	1) Raise eyebrows 2) Widen eyes 3) Mouth wide open 4) Furrowed eyebrows 5) Tilted back, body or head

Table 5:4: Number of facial actions per emotion (significant difference between groups marked by *)

Another caveat for the physical explanation is that findings also demonstrate that recognition of the affective facial expression ‘mischief’ is impaired in addition to production (see chapter 4). Therefore a more likely explanation for the impairment in the production of the ‘mischief’ facial expression is that the deaf ASD group appear to have difficulty with both the comprehension and production of mischief in the context of BSL usage. It is suggested that primary difficulties with expressions utilising ToM may impinge on their usage and recognition during sign discourse. This idea gains currency from the fact that hearing individuals with ASD are also impaired with recognition of mischief and deception (Baron-Cohen, 1992; Sodian & Frith, 1992; Dennis et al., 2000).

The deaf ASD group may be impaired with ‘demand’ facial expressions because they have a unique role, for example when participants retell the story, they still produce the manual sign for demand and demonstrate awareness that the boy is asking the girl for various food items. However they omit to produce facial action targets for demand, which

demonstrates the style in which the boy asks (e.g. threatening tone). These findings are in line with Hobson and Hobson (2008) who demonstrated that individuals with ASD are able to imitate actions but not the style in which actions are carried out. Demand is also unique in that its manual sign is produced as a gesture by the characters in the narrative. The presence of this gesture may facilitate the deaf control group but not the deaf individuals with ASD. There is evidence that hearing individuals with ASD are impaired with gestures (Atwood et al., 1988; De Marchena & Eigsti, 2010).

Both demand and mischief are not strictly emotions, therefore differences between groups with the production of these facial expressions may stem from an alternative explanation than impaired production of affective facial expressions in the deaf ASD group

Some findings are inconsistent with the results of other research studies. In the current experiment the deaf ASD group unlike their hearing counterparts, were unimpaired with producing facial expressions of disgust. Law Smith et al., (2010) provide evidence for an impairment with the perception of disgust in hearing individuals with ASD. They gave individuals with ASD and typically developing controls an emotion recognition task (Montagne et al., 2007) consisting of six affective facial expressions ('anger', 'disgust', 'fear', 'happy', 'sad' and 'surprise') which varied in intensity. They found that individuals with ASD were impaired with anger, surprise and disgust at low intensities compared to typically developing controls, however an impairment with the processing of disgust was particularly significant at all levels of intensity for the individuals with ASD, meaning that it is surprising that the deaf ASD group were not only able to recognise 'disgusted' expressions within the scenario, they were also able to accurately produce BSL expression targets.

The deaf ASD group were unimpaired with the production of surprise facial expressions in this experiment and several studies demonstrate impairments with the perception of surprise in ASD (Capps et al., 1992; Baron-Cohen et al., 1993; Castelli, 2005). However these research studies only measure perception of these emotion types and not production, therefore differences may be attributed to type of task. Alternatively it is possible that the lack of impairment for 'surprise' is due to task characteristics, because when the girl character produces the facial expression of surprise in the filmed scenario, it is related to her surprise at seeing the spider rather than her surprise about another person and their beliefs, so this does not have such a substantial ToM component. Expressions of surprise involving belief attribution (e.g. surprise at the boy's actions) may reveal an impairment in individuals with ASD (unfortunately more general facial expressions (e.g. happy, sad, angry) were not analysed in this task, as they did not occur in the story).

The fact that one of these emotion types was produced by the boy (demand) and the other was produced by the girl (mischief) suggests no differences in expression clarity attributable to the different actors, likewise frequency of emotion occurrence within the video does not account for the group differences found with 'demand' and 'mischief', since 'demand' appears in the narrative four times, whereas 'mischief' appears only twice. Nevertheless participants may show a recency effect, as the single occurrence of the facial expression of disgust is produced right at the end of the video and the deaf ASD group have slightly better accuracy for this emotion type than controls. Additionally endpoints of narratives are usually recalled more accurately due to the semantic climax of the story (Poulsen et al., 1979; McCabe & Peterson, 1990).

The BSLNST is standardized with native and non-native signing deaf children. The characteristics of the scenario used, may contribute to some of the group differences that emerged (e.g. with expressions of ‘demand’ and ‘mischief’). Understanding required a second order knowledge of false belief (e.g. individuals had to understand that 1) the girl put the spider in the sandwich because she knew the boy would ask for more food and 2) that the boy didn’t expect there to be a spider in the sandwich). This is quite a complex false belief task. Hearing individuals with ASD have been shown to have deficits with ToM, and often fail false belief tasks (Baron-Cohen et al., 1993; Peterson & Siegal, 1999; Dennis et al., 2000). Similarly deaf children from hearing families where they do not have exposure to language often have delayed ToM ability compared to hearing children passing these false belief tasks at a later age (Peterson & Siegal, 1995; Woolfe et al., 2002).

Another caveat for this ToM explanation is the similar narrative content, structure and question comprehension scores for both groups suggesting that they both understood the narratives to the same extent. However whilst the questions are good indicators of understanding, they do not directly measure if participants fully understood the false beliefs in the story. Some studies suggest that there is a relationship between children’s ToM ability and their use of emotional/mental state language in narratives (Ziatas et al., 1998; Capps et al., 2000; Tager Flusberg, 2003). Presuming that this finding holds for deaf individuals with ASD it would be important to know how they fare with false belief tasks, establishing the extent of their impairment in future studies. Specific tests of ToM would be central to further explore the hypothesis that there is a relationship between ToM and the use of affective facial expressions in the deaf ASD group. The non-verbal cartoon recall task used by Morgan and Kegl (2006) with Nicaraguan deaf children would be a useful

measure, as the number of mental state signs and facial expressions elicited during this story could be compared between groups. For example in this study the authors found narrative difficulties with the use of deception in deaf children. Additionally it would be interesting to give both groups a narrative that did not incorporate ToM or deception at all to compare whether they produce affective facial expressions any differently. A scenario without false belief may not have revealed group differences, as expressions that have a ToM component (e.g. mischief) may not be produced.

Another possible factor which may have influenced production of affective facial expressions in the BSLNST task is the dynamic real time nature of the actors facial expressions, which may have had a facilitatory scaffolding effect, encouraging greater use of expression among the ASD group, than would have been produced if the actors face had not provided a model. These facial expressions may have been imitated by the participants, making the task a less naturalistic measure of facial expression production. However the time delay between watching the video and producing the narrative means that immediate imitation was not possible. Factors including memory, interpretation and understanding of the narrative may be more salient.

When retelling the narrative participants were not specifically instructed to copy the facial expressions of the characters. This may be problematic as hearing individuals with ASD perform better after being explicitly told to copy other people in tasks (Loveland et al., 1994; McIntosh et al., 2006), especially on tasks involving imitation or attention to facial affect when they are given explicit instructions to attend to the face (Wang et al., 2007). Loveland et al., (1994) compared groups with ASD and Down's syndrome on their ability to produce facial expressions. The ASD group had difficulty generating facial

expressions (without copying a model) but showed successful rote copying of facial expressions, the group with Down's syndrome showed the opposite pattern with better self-generation than imitation. McIntosh et al., (2006) conducted a more recent study supporting the need for explicit instruction. They investigated the role of instruction on the facial imitation performance of groups with ASD and matched controls. Participants were presented with pictures of people showing 'happy' and 'angry' facial expressions. In the automatic condition participants were instructed to passively watch the pictures as they appeared on the computer screen, in the voluntary condition they were instructed to make an expression just like the picture. Facial expressions were measured using facial electromyography of cheek and eyebrow movements. Controls showed imitation of facial expressions for both conditions, however the individuals with ASD only produced facial expressions when they were explicitly instructed to do so. It is therefore likely that if the deaf ASD group had been specifically instructed to produce the same facial expressions as the characters in the narrative, they may not have shown the same degree of impairments documented in the current findings.

Other methodological issues involve an increased task load, participants had to watch, interpret and memorize a two minute narrative so they could retell it to an experimenter and answer questions at the end.

In conclusion, the deaf ASD group produced fewer affective facial expression targets for some emotion types (e.g. demand and mischief) compared to deaf controls. They also differed in the quality of affective facial expressions produced compared to the controls with fewer identical facial expressions. These findings are important because they demonstrate that deaf individuals with ASD do show impairments with producing affective

facial expressions in quantity and quality, in line with their hearing counterparts. However, it is necessary to ensure that this impairment is not just ToM specific by measuring the facial expression production of deaf individuals with ASD using a methodology that does not involve ToM. Chapter 6 explores in detail production of both affective and linguistic facial expressions in BSL using a sentence repetition paradigm. This paradigm is beneficial for a number of reasons it does not require ToM ability and furthermore repetition rather than narrative elicitation methods may have reduced task demands leading to fewer differences between groups and further insights into the mechanisms causing production impairments.

Chapter 6: How do deaf individuals with ASD produce linguistic and affective facial expressions in a sentence repetition task?

Introduction

Linguistic facial expressions

Sign language uniquely conveys both affective and linguistic information on the face. In sign language facial expressions have a dual function, they show affect, as they do with spoken language and they have an added linguistic function (Corina et al., 1999). The current chapter investigates how deaf individuals with ASD produce affective and linguistic facial expressions in BSL, when they are instructed to copy a signer in a sentence repetition task. Baker-Shenk (1983) noted that in sign languages linguistic and affective facial expressions can be distinguished from each other in a number of ways: 1) affective facial expressions vary in intensity and can occur at any point in the production of a sentence, 2) they do not necessarily occur with a specific manual sign, unless they are manual signs for emotion (e.g. HAPPY, where a congruent happy facial expression would be mandatory). By contrast linguistic facial expressions must occur at specific rule-governed points in the signed utterance in order for the signed utterance to appear as grammatically normal, 3) affective facial expressions are expressed using global facial actions, whereas linguistic facial actions may use isolated facial parts (e.g. eyebrows, eyes or mouth).

Linguistic facial expressions may be produced with more than one facial feature, each facial feature can have more than one function (e.g. the eyebrows may raise or furrow and eye lids may contract or widen, revealing different meanings). These facial arrays can reveal complex linguistic meaning, for example an eyebrow raise may suggest that the utterance will contain relevant information or a consequence (Sandler & Lillo-Martin, 2006). Specific combinations of facial behaviours act as the required morphological

markers for these linguistic structures in sign language (for more details of types of linguistic structures in BSL see chapter 1). Figure 6:1 demonstrates a Wh question being manifested by a manual sign WHAT with facial features of eyebrow squint, head tilt and continuous eye gaze.

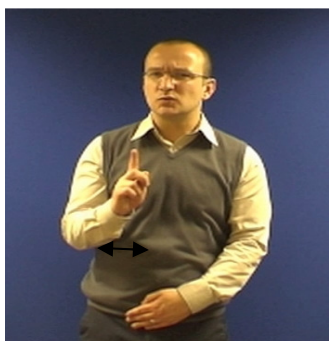


Figure 6:1: Example of Wh question in BSL (WHAT)

Researchers are divided in their opinion on the function of linguistic facial expressions, Liddell (1980) believes that they have a syntactic role, whereas other researchers believe linguistic facial expressions function more like intonation in speech (Reilly et al., 1990; Wilbur, 1991) (see chapter 7 for more details). McIntire and Reilly (1988) proposed a three way classification for grouping facial expressions seen during signed discourse: 1) those which are uniquely affective (e.g. 'surprise', 'happy'), 2) those which have overlap with pre-existing communicative behaviours (e.g. negation: head shake, Wh questions: eyebrow raise) and 3) those which are unique to the grammar of signed languages (e.g. adverbials).

Neural localisation

There is growing evidence from studies of deaf signers with brain lesions that linguistic and affective facial expressions have separate function and discrete neural localisation (Corina, 1989; Kegl & Poizner, 1996; Emmorey, 2002; Penn et al., 2007). The left hemisphere (LH) has been widely established as the location of linguistic abilities for both speakers and

signers (Corina et al., 1999, Witelson & Pallie, 1973), whereas the right hemisphere (RH) is implicated in emotion processing including affective facial expressions in hearing and deaf people (Harley, 2001; Emmorey, 2002). There is a growing literature demonstrating that sign languages exploit (albeit to a much lesser extent than the LH) the capabilities of the RH, because of the unique visual spatial and facially expressed syntax, which does not occur in spoken language (Newman et al., 2001). Kegl and Poizner's (1996) case study of an American signer with LH damage showed an interesting dissociation between intact production of facial expressions where they had an affective role but impairment where they served a linguistic purpose. This double dissociation was mirrored in a study by Corina et al., (1999) comparing LH and RH damaged signers during a narrative task and spontaneous conversation. The RH lesioned signer had clear cut deficits with facial affect, despite commanding a full range of linguistic facial expressions for questions, negations, embedded clauses, topic markers and adverbials. The ratio between affective and linguistic facial expressions was 1:4. In stark contrast the aphasic LH damaged signer showed wholly intact use of affective facial expressions, with an absence of linguistic facial actions with a production ratio of 6:1. Few examples of linguistic facial expressions were produced and many syntactic and adverbial markers were notably absent. The same dissociative pattern of deficits was noted by Penn et al., (2007). They compared different groups of deaf clinically impaired signers including learning disabled signers (LD) and signers with right hemisphere (RH) damage). The LD group showed linguistic impairments with deficits in classic sign language comprehension tasks, whereas the RH group had increased difficulty with affective facial expression production and the use of narratives. These findings all confirm the localization of linguistic facial expressions to the LH and affective facial

expressions to the right. There is a complete dearth of research exploring linguistic and affective facial expressions in signed production of deaf individuals with ASD. Both hearing individuals with ASD and those with RHD show face processing, communicative and prosodic (intonational) impairments (MacDonald et al., 1989; Ozonoff & Miller, 1996; Shields et al., 1996; Sabbagh, 1999; Peppe et al., 2007). Therefore it is possible that deaf individuals with ASD will resemble deaf individuals with RH damage showing a dissociative impairment in affective expressions with preserved linguistic facial behaviours.

Hearing people with ASD

There is some limited evidence that hearing individuals with ASD show better performance on linguistic tasks (which centre on the face) than affective face processing tasks (De Gelder et al., 1991; Grossman & Tager Flusberg, 2008). De Gelder et al., (1991) compared children with ASD and matched controls on two tasks: 1) a test of memory for unfamiliar faces using the Kaufman face recognition test for children (Kaufman & Kaufman, 1983) 2) a test measuring their lip-reading ability using a facial speech reading test. Participants' were required to repeat phrases using audiovisual, auditory only and visual only recordings from a female speaker. Children with ASD were found to be poorer at remembering faces compared to controls, but they showed comparable lip-reading performance. Grossman and Tager-Flusberg (2008) conducted a similar study participants were required to sort photos in consecutive order in two different tasks: 1) a linguistic task- participants were shown a sequence of still images of a model lip-reading four words with frames illustrating the beginning to the end point of each word (e.g. 'bath', 'thumb', 'watch'). Participants were asked to sort the sequences depicting each word from the beginning to end (e.g. B A A TH). 2) Affective task- participants sorted images to match the order in which a person

produced an affective facial expression (e.g. 'happy', 'sad', 'disgust', 'fear') in the same way. Findings revealed the ASD group were better at sorting the images of the lip-read words compared to the affective facial expressions, whereas the reverse pattern was found for controls. Taken together, findings from these studies suggest that hearing individuals with ASD may have better preserved recognition of facial actions when their function is linguistic and this stands in contrast to poorer skills with faces in other contexts such as general recognition or the processing of affective expressions. It remains to be seen whether a similar privileging of the face in linguistic contexts will occur for deaf signers with ASD. It is hypothesised that this group will show a similar pattern with a relative sparing of production ability for facial actions which are deemed linguistic and central to the BSL production lexicon compared to facial actions which have a purely affective function.

Affective facial expressions- methodological issues

In chapters 4 and 5 a body of research indicating impaired recognition and production of affective facial expressions in hearing individuals with ASD was reviewed (Yirmiya et al., 1989; Phillips et al., 1992; Loveland et al., 1994; Volker et al., 2009; Philip et al., 2010) and a similar pattern of findings was extended to a small group of deaf signers with ASD, there were difficulties with the comprehension and production of some affective facial expressions compared to deaf controls with impairments in recognition of 'happy', 'angry' and 'mischief' facial expressions and the production of 'demand' and 'mischief' facial expressions. Whilst it is probable that these findings stem from impairments with emotional facial expressions, particularly in contexts that demand ToM, these findings may have arose because of methodological issues. The sentence repetition task was selected as it allows for explicit instructions and it has reduced task demands and cognitive load.

Sign language sentence repetition

There are few studies to date which have used sentence repetition tasks with deaf signers (Mayberry et al., 1983; Hickok et al., 2002; Hauser et al., 2006). Hauser et al., (2006) looked at sentence reproduction, comparing 99 deaf and hearing native and non-native signing children (native deaf n=27, hearing native n=5, non-native deaf n=13, hearing n=0, mean age 12.9), and adults (native deaf n= 23, hearing native n=25, non-native deaf n=4, hearing n=2, mean age 27.6) on a pilot version of the American Sign Language sentence reproduction test (ASLSRT). It consisted of 40 sentences of graded complexity. Non-native signers (deaf and hearing) had a mean score of 42.5% on the ASLSRT and native signers (deaf and hearing) scored 62.5%. However these scores did not reflect repetition of facial expressions, they involved scoring of exact matching of manual signs produced in the test. The BSL sentence reproduction test is currently being developed at DCAL (Cormier et al., 2010) based on the ASLRST. A trend for flattening of facial features for imitation of sentences with increasing complexity has been noted (Atkinson, 2011, personal communication) however this finding was not reported in Hauser et al.,’s (2006) paper. There have been even fewer studies, which specifically look at the repetition of facial expressions in sign language. Anderson and Reilly (1998) looked at how linguistic adverbial facial expressions are acquired in ASL by 15 young children aged between the ages of 2:8-4:8. Children were given a sentence repetition task and they were asked to imitate 20 sentences. Half of these sentences were grammatically correct with appropriate use of adverbial facial expressions and half were ungrammatical, with manual signs which were erroneously paired with adverbial facial expressions (e.g. the adverbial for very thin object being presented alongside the manual sign for a large object). All children were able

to reproduce the facial adverbials well, with 14 of the 15 children showing performance at an 80% accuracy level. Children were also good at repeating the stimuli with the manual and NMMs showing appropriate timing and scope. This suggests children are able to effectively imitate adverbial facial expressions from a young age. Children fared better with this task compared to Hauser's complex sentence repetition task, as the ASLSRT uses complicated language and lengthier structures.

There are only two known sign language repetition tasks, which distinguish between sentences with linguistic and affective facial expressions. The first was used by McIntire and Reilly (1988) in an investigation of how hearing adult students of sign language acquire facial expression in ASL. They tested two groups of 1) advanced learners (n=10) and 2) beginners (n=10). Both groups were given an ASL sentence imitation task featuring facial expressions which included both affective ('surprise', 'disgust' and 'sadness') and linguistic facial expressions (negation, questions, adverbials, topics and conditionals). This was administered live by a native signer. For ease of scoring and a comparison, baseline scores were taken from two deaf models who were late learners of ASL. Facial expressions produced were coded in four ways: 1) in quantity (this was calculated as a percentage of those produced by the deaf models) 2) whether the scope/timing matched those of the model 3) whether participants produced different facial expressions to the models (i.e. missing constituents or substitutions) and 4) whether the response was grammatical. The authors hypothesised that the hearing learners would be good at imitating affective facial expressions and linguistic facial expressions that are similar to communicative facial expressions in spoken language (e.g. yes-no questions and negation). Findings were consistent with the hypothesis, participants in both groups

produced more facial expressions for affective and linguistic communicative behaviours also seen in English, however they produced fewer linguistic facial expressions where they were unique to sign language (e.g. adverbials, conditionals and topics). Learners attended to facial expressions in sign language, but did not know the rules governing their usage.

In a second study Woll and Rentelis (2009) tested deaf and deaf-blind adults on their ability to produce facial expressions in a sentence repetition task. They gave deaf-blind participants signed sentences using tactile sign language (where the deaf-blind individual perceived signed input by placing their hands on top of those of their conversational partner (Petronio & Dively, 2006)). As a comparison deaf normally-sighted participants were shown a video of a signer producing identical sentences with the signers face blocked out, so they could not see the facial expressions. All participants were explicitly asked to repeat the sentences using facial expressions that they thought matched the sentence (but that they could not see). Therefore they were not repeating the use of the face that they had seen, but were being tested to see if they had knowledge of the correct linguistic facial action and could apply them to the sentences that they were given. The sentence repetition task consisted of 40 sentences: 20 of the sentences required the use of facial expression, 10 of these were sentences referring to emotional states and 10 were linguistic sentences, with descriptions regarding the properties of objects. The other 20 sentences were control sentences, which did not require any specific facial expressions. It was hypothesised that deaf-blind signers would produce less facial expression, as a result of having a lack of signed input from the facial expressions of others. Findings were consistent with this hypothesis demonstrating that the deaf-blind signers produced fewer facial expressions for all sentence types in comparison to the deaf controls. No differences for linguistic and

affective sentences were found. These experiments testify to the appropriateness of sign sentence repetition as a task methodology for eliciting and contrasting the production of linguistic and affective facial actions in users of sign language.

ASD and imitation

The tendency for people with ASD to do better with affective expressions when they were explicitly instructed to copy others has already been noted (Loveland et al., 1994; McIntosh et al., 2006). However on the other hand several research studies have also documented specific imitation deficits in individuals with ASD (Smith & Bryson 1994; Hobson & Lee 1999; Rogers et al., 2003; Hobson & Hobson, 2008; Ingersoll, 2008; Sevillever & Gillis, 2010). The most common types of impairments occur with imitation of facial expressions, body movements and gestures rather than a global impairment per se (Stone et al., 1997; Rogers et al., 2003). Several other studies have demonstrated no differences in imitation ability in individuals with ASD and controls (Hamilton et al., 2007, Southgate et al., 2009). Findings can be inconsistent and can depend on a number of factors including: the definition of imitation adopted, the type of act to be imitated and the methodology that is used (Sevillever & Gillis, 2010).

In experiment 4 a sentence repetition task was developed requiring the repetition of sentences featuring both linguistic and affective facial expressions. This methodology allowed the production ability of both groups to be compared across the two types of facial action using quantitative and qualitative analyses.

Experiment 4

Hypothesis

A number of scenarios can be expected from the current experiment

1) *There will be no differences between groups in the number and quality of facial expressions produced for both affective and linguistic facial expressions due to the reduced task demands conferred by imitation methodology and the absence of ToM requirements associated with the current task.*

2) *An alternative hypothesis states that linguistic and affective facial expressions will be differently impaired in line with De Gelder (1999) and Grossman and Tager Flusberg's (2008) findings, with the deaf ASD group producing a greater quantity and quality of linguistic facial expressions compared to affective facial expressions (within group differences) and the deaf ASD group being impaired relative to controls for affective facial expressions but not linguistic expressions (between group differences).*

3) *Another potential outcome is that in light of deficits in imitation in individuals with ASD, the deaf ASD group may have reduced repetition of both linguistic and affective facial actions.*

We propose that hypothesis 1 will be supported.

Methodology

Participants

Deaf ASD group (n=13) and deaf controls (n=12) were tested (see chapter 2 for group matching characteristics).

Materials

The sentences for the sentence repetition test were devised by Professor Jane Marshall and Dr Joanna Atkinson, a clinical neuropsychologist and second supervisor of the thesis. They had been used for the assessment of deaf atypical signers in case studies (e.g. with deaf signers with stroke). Twenty-three BSL sentences were produced onto video by a deaf adult native signer, filming took place at DCAL. Each sentence was approximately 8 seconds long. Each sentence was edited so that after it played, a black screen was presented for 4 seconds. Piloting demonstrated that this time frame was sufficient for participants to repeat the sentence. Thirteen of the sentences used linguistic facial expressions: these sentences were varied in type consisting of adverbials (3), negation sentences (4), conditionals (4) and adjectives (2) (examples are shown below in Figures 6:2-6:4).



Figure 6:2: Example of adverbial facial expression and manual sign for DRIVE MM (drive in relaxed manner)



Figure 6:3: Example of negation manual sign NOTHING and facial NMM for negation



Figure 6:4: Example of a conditional facial NMM and manual sign RAIN



Figure 6:5: Example of affective facial expression for surprise and manual sign EARLY

The remaining sentences (10) used affective facial expressions consisting of ‘sad’ (3), ‘annoyance’ (2), ‘surprise’ (1) (see Figure 6:5), ‘happy’ (2) and ‘disgust’ (2). Table 6:1 lists English glosses of the BSL sentences used and describes their corresponding facial action.

Gloss (English description)	Facial actions	No of targets	Affective/linguistic
ARM HURT (My arm hurts)	eyebrows furrowed	1	A
DOCTOR PHONE (I phoned the doctor)	eyebrows raised then furrowed	2	A
DOG HE BRING (He brought his dog)	eyebrows raised then furrowed	2	A
HUNGRY ME EAT SANDWICH (If I am hungry I will eat a sandwich)	eyebrows raised at beginning	1	L
SMELL FOOD (Mm I smell food)	eyebrows raised for whole duration	1	A
HOT ME OPEN WINDOW (If I am hot I will open the window)	eyebrows raised for hot then furrowed for open window	2	L
MAN CAR PUSH (The man pushed the car)	eyebrows raised for man then furrowed for car push	2	L
MAN HE FAT (That man is fat)	eyebrows raised for man then furrowed for fat, puff cheeks	3	L
MOUSE ME SAW (I saw a mouse)	eyebrows raised for mouse then furrowed for I saw	2	A
WOMAN POINT HUNGRY NO (That woman isn't hungry)	eyebrows raised for most of sentence, pursed forward lips for no	2	L
FISH WE EAT (We ate the fish)	eyebrows raised for fish, furrowed for we eat	2	A
WOMAN NOTHING MONEY BOY HAVE (The woman doesn't have any money, but the boy does)	eyebrows raised at beginning, furrowed at end, head shake for nothing	3	L
ME HOME EARLY (I got home early)	eyebrows raised for whole sentence	1	A
ICE-CREAM WE EAT (We ate icecream)	eyebrows raised for whole sentence	1	A
MAN GO PARK DRIVE (The man goes for a drive to the park)	eyebrows raised for whole sentence, lips pursed forward for drive	2	L
PRESENT POINT GIRL GIVE (The girl gave me the present)	eyebrows raised for whole sentence	1	L
SNOW ME PUT BOOTS ON (If it snows I will put my boots on)	eyebrows raised for snow and furrowed for put boots on	2	L
UNCLE COME (My uncle is coming over)	eyebrows raised for uncle and furrowed for come	2	A
RAIN PARTY OFF (If it rains the party will be cancelled)	eyebrows raised for rain furrowed for off	2	L
MAN GO PARK WALK (The man goes for a walk in the park)	eyebrows raised for whole sentence, lips pursed forward for walk	2	L
MAN POINT FAT WOMAN POINT NO (The man is fat but the woman is not)	eyebrows raised for man, woman, furrowed for fat, no, lips downturned for no and head shake, PUFF cheeks	5	L
HE LEFT YESTERDAY (He left yesterday)	eyebrows raised for he, furrowed for left yesterday	2	A
MAN POINT CAR VEE WOMAN POINT HAVE (The man doesn't have a car, but the woman does)	eyebrows raised for man car and woman, furrowed for vee, have	2	L

Table 6:1: Sentences and facial actions in sentence repetition test

Procedure

Participants were presented with a video playlist of the signed sentences on the screen of a laptop and were instructed to copy each sentence exactly, after they saw a black screen. There were two practice sentences (one affective, one linguistic), they were played to ensure that participants understood the nature of the task and did not respond too quickly. Reminders were given to wait for the black screen if necessary. This ensured that the task tapped recall rather than shadowing abilities Repetition of the stimuli was permitted if a sentence was missed. This happened very infrequently. The whole task took no longer than 7 minutes. All participants viewed the sentences in the same order; the order of the stimuli was fixed to ensure that no more than two linguistic or affective sentences occurred consecutively. Responses were recorded using a video camera.

Coding System

Videos were coded using ELAN. A face expression coding system was developed using the test stimuli (produced by one deaf native signer) and two deaf adult native signers as models (see chapter 5 for details). They completed the repetition task and their filmed responses were coded to capture BSL facial actions during the copying task. For each sentence the number of facial action targets was identified. For example the sentence MAN FAT was produced by the three signers with raised eyebrows, followed by furrowed eyebrows and puffed cheeks. Therefore three targets were assigned to this sentence and the number of facial action targets that each child produced for this sentence would be rated against this target number. Where the number of targets was not consistent between the three signers on any given sentence, the average number produced was used. Each video-

clip in ELAN was paired with a template which had three tiers in it (see Figure 6:6). The three tiers consisted of: 1) the target number of facial actions based on those produced by the deaf adult models 2) a marker of how many target facial actions the participant produced for the same sentence and 3) the quality of participant responses was also rated by comparing the adult models' production of the same sentence. The coding system used is described in detail in chapter 5. Responses were labelled identical, similar, miscellaneous and blank. Miscellaneous facial actions were labelled when a facial action was made that clearly did not add to the meaning or accompany the sign (e.g rolling of the eyes or tongue protrusion).

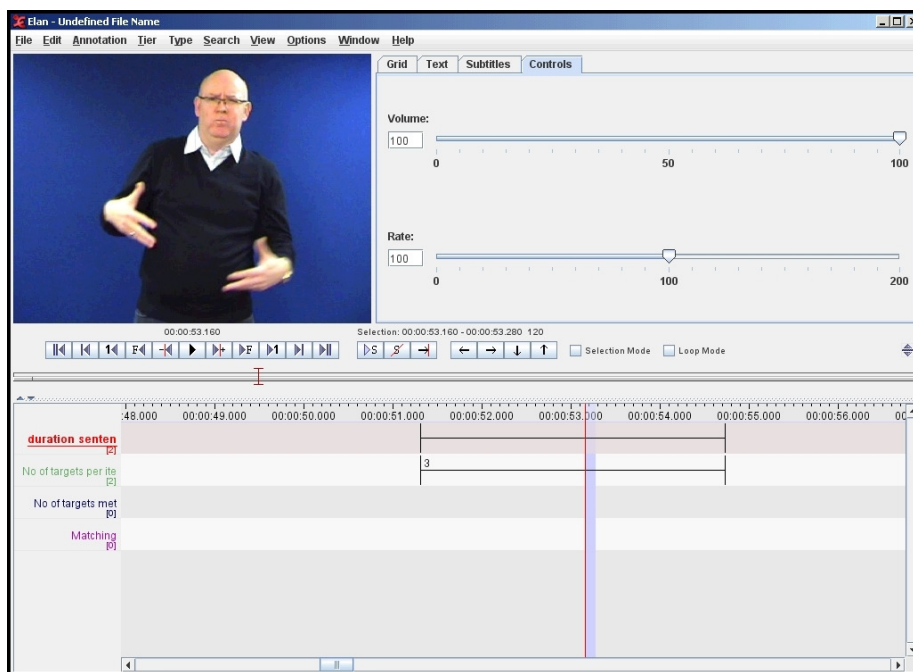


Figure 6:6: ELAN coding sheet for facial actions

Results

The mean number of facial actions made in response to linguistic versus affective sentences is shown in Figure 6:7, both groups showed higher mean scores (%) for linguistic (ASD:

Mean: 45.5, SD: 21.5, controls: Mean: 56.1, SD: 20) than affective facial expressions (ASD: Mean: 43, SD: 18.2, controls: Mean: 46.2, SD: 21.2). These data were analysed using a mixed Analysis of Variance (ANOVA) with group (ASD, control) as a between subjects factor and sentence type (linguistic, affective) as a within subjects factor. There was a main effect of sentence type ($F(1, 23) = 4.987, p < .001$). There were no significant interactions between factor and group and there was no significant main effect of group.

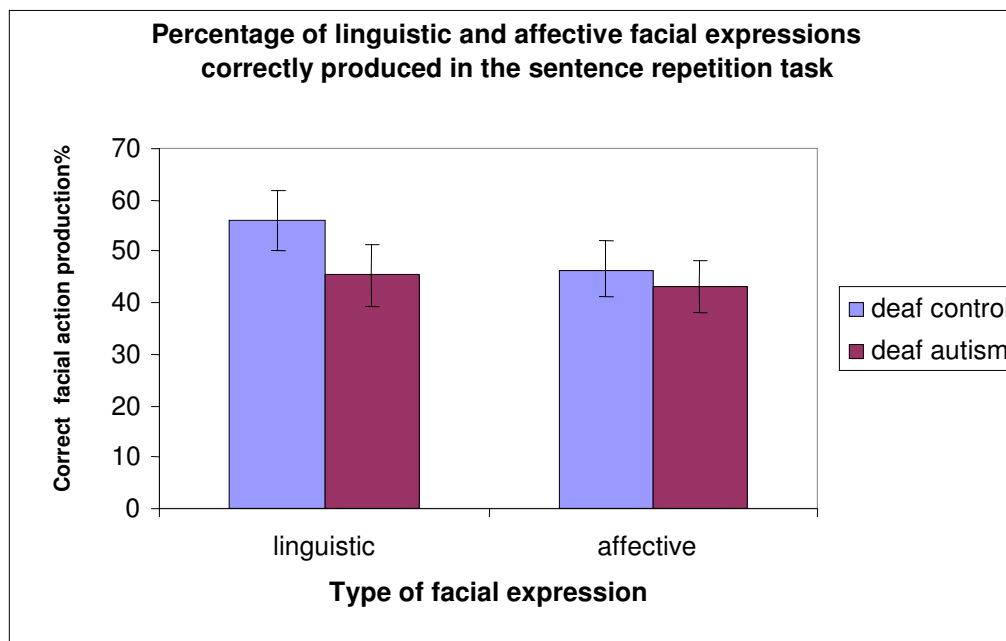


Figure 6:7: Production of linguistic and affective facial expressions in a sentence repetition task for the deaf ASD and control groups

A deaf adult native signer coded a 20 % subsample of the data for quantity of facial actions. The rater was blind to the experimental group of the participants (3 deaf ASD and 2 deaf controls). An intraclass correlation was carried out and similarity between the raters was .932.

Linguistic facial expressions

A t-test demonstrated that there were no group differences for quantity of linguistic facial actions produced ($t(23)=1.3$, $p>.05$). For quality measures there were no differences between groups in the number of blank linguistic facial actions produced. Of the non-blank linguistic facial actions (identical, similar and miscellaneous, see chapter 5 for details of how these were coded and scored), Mann Whitney non-parametric tests were conducted to determine if both groups differed in their productions. Deaf controls produced significantly more facial action targets rated ‘identical’ than the deaf ASD group ($U(25)=26.5$, $p<.05$). However the latter group produced significantly more ‘similar’ linguistic facial action targets than the deaf controls ($U(25)=29.5$, $p<.05$) indicating that their expressions were more approximate and less exact. There were no significant differences between groups for miscellaneous facial actions (see Figure 6:8).

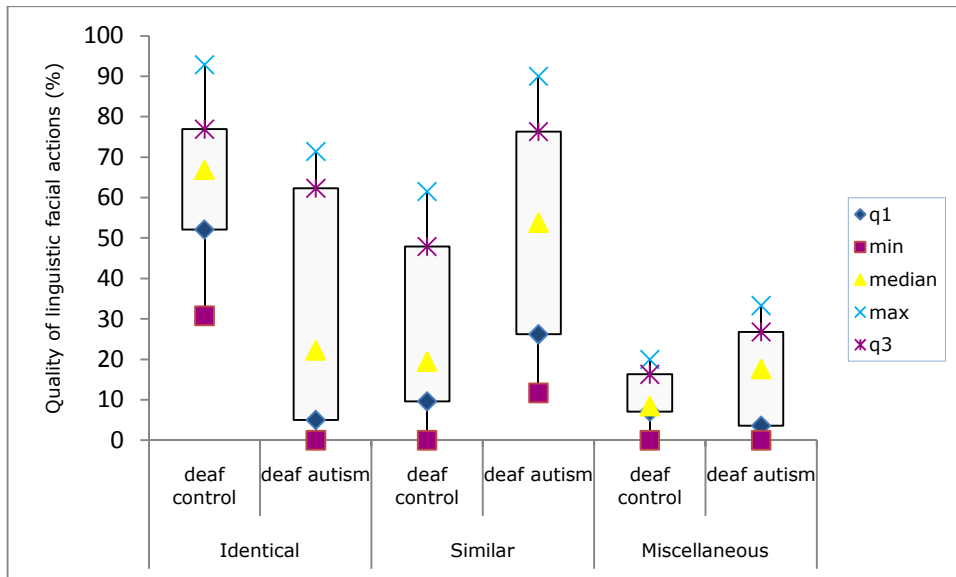


Figure 6:8: Proportion of quality scores (%) for linguistic facial expression targets in both groups on the sentence repetition task.

Affective facial expressions

A t-test demonstrated no group differences in quantity of affective facial expressions ($t(23)=.39, p>.05$). For affective facial action targets there were no differences between groups in blank and non-blank productions, the same trends were found for quality between groups for non-blank coded facial targets (e.g. controls more identical and ASD more similar productions), but these did not reach significant levels (see Figure 6:9).

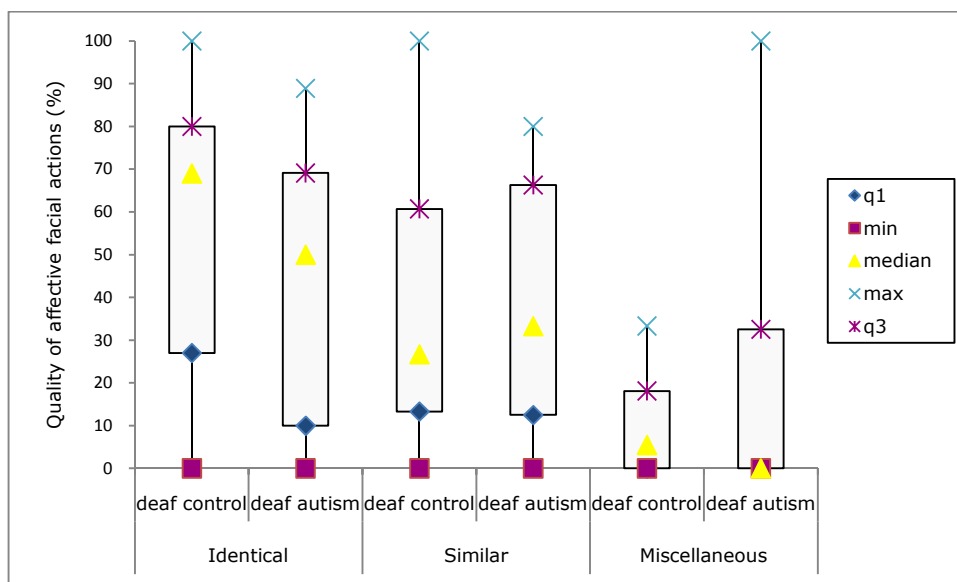


Figure 6:9: Proportion of quality scores (%) for affective facial expression targets in both groups on the sentence repetition task

Figure 6:10: An example ELAN transcription of a linguistic sentence (e.g. negation) being produced by a deaf individual with ASD in the sentence repetition test.

Figure 6:11: An example ELAN transcription of an affective sentence (e.g. SAD) being produced by a deaf individual with ASD in the sentence repetition test

Figure 6:12: Example of deaf control producing a linguistic sentence (e.g. FAT-adverbial, No- negation) in the sentence repetition test.

The ELAN still frames depicted in Figures 6:10 and 6:11 show that deaf individuals with ASD do attempt to produce facial action targets during sentence imitation. However replications are often partial rather than exact. Figure 6:10 demonstrates a deaf individual with ASD producing a linguistic sentence using negation, she only produces one facial expression target out of a possible three: lip protrusion, she does not furrow her eyebrows or shake her head negatively. Similarly a deaf boy with ASD in Figure 6:11 produces an affective sentence conveying sadness (HE LEFT YESTERDAY), he demonstrates 2 out of 5 facial targets, with furrowed eyebrows and a down turned mouth, however he omits 3 target facial actions including: eyebrows, head nod and head shake. The deaf control participant in Figure 6:12 produces a linguistic sentence using negation and the adverbial ‘puffed cheeks’ for (MAN FAT, WOMAN NO). She produced 4 out of 5 targets (puffed cheeks, furrowed eyebrows, head shake and down turned mouth) with the only one omission in raised eyebrows at the beginning of the sentence.

Discussion

The results indicate that the deaf ASD group was not significantly impaired relative to deaf controls in the *quantity* of both linguistic and affective facial expression targets, therefore hypothesis 1 was supported. However there were some significant differences in the *quality* of linguistic facial actions between groups. Deaf control productions were rated as more identical to model targets, whereas the ASD group produced more approximate facial actions, which were rated as similar rather than identical. The same pattern of findings occurred for the imitation of affective sentences but the difference between groups was not

significant. The fact that the ASD group produce a similar quantity of facial actions which approximated targets, suggests that the imitation task was well understood. However the qualitative differences in their rendition of linguistic facial actions leads to two possibilities. Firstly the ASD signers may have a less complete repertoire of facial actions upon which to draw during this task (top down knowledge) or secondly, they may be using a more inefficient bottom up strategy in imitation, relying to a greater extent on working memory and to a lesser extent on learned linguistic knowledge about appropriate facial actions in BSL.

These findings somewhat dispute hypothesis 1 (which stated that there will be no differences between groups in the number and quality of facial expressions produced for both affective and linguistic facial actions) demonstrating that there may be a subtle difference in how accurately the deaf ASD group produce linguistic facial actions in terms of quality compared with controls. However in terms of the affective facial actions hypothesis 1 is supported. Hypothesis 2 (which stated that linguistic and affective facial expressions will be differently impaired with within group and between group differences) is only supported for quantity but not quality. This finding was also not unique to the deaf ASD group, as deaf controls also produced more linguistic than affective facial expressions.

These findings do not replicate the findings of group differences in previous chapters (e.g. in chapter 5, the deaf ASD group produced fewer affective facial expressions than controls). These findings suggest that imitation is easier for the ASD group, which does not support hypothesis 3 (that the deaf ASD group may be impaired as a result of imitation deficits which are associated with autism). These findings are in line with Press et al., (2010) who found that adults with ASD and controls had similar performance when

imitating neutral, angry and surprised facial actions. Performance was measured by comparing whether their mouth and eyebrows were compatible or incompatible with these facial actions and speed of action was also measured by motion tracking equipment. This imitation methodology appears to reduce impairment relative to controls. However, it remains speculative as to which element of the imitation task enabled the deaf ASD group to perform more closely to controls, several factors are likely to be facilitatory including: explicit copying: reduced memory demands and reduced spontaneity of the task. Further research manipulations would be required to rule out these explanations.

Anderson and Reilly (1998) reported that deaf children produced adverbial facial expressions during sentence repetition at an earlier age than they did in their spontaneous language use. This suggests that deaf children may be able to repeat signs prior to having mastered their production. Therefore the deaf ASD group may be impaired relative to controls using other methods of elicitation, as sentence repetition tests are not solely reliant on top down knowledge (true language and emotional processing ability) but allow the recruitment of bottom up processing where the repetition involves mimicking without deeper understanding.

The finding that both groups do not differ on the quantity of facial expression targets produced is not in line with the literature, as several studies have demonstrated that hearing individuals with ASD are impaired with specific elements of imitation relative to controls (Hobson & Lee, 1999; Hobson & Hobson, 2008; Ingersoll, 2008) and with imitation of facial acts (Stone et al., 1997; Rogers et al., 2003). However differences in scoring systems need to be considered in accounting for the discrepancy in findings

between different imitation tasks, as some studies just score for the presence or absence of imitative acts rather than quality of imitation (Hobson & Hobson, 2008).

Participants in both groups appear to have quite low scores for imitation of both linguistic and affective facial expressions on the sentence repetition test (range of 45-60%), this finding is somewhat consistent with Hauser et al.,’s (2008) study. Anderson and Reilly (1998) found higher scores for facial expressions on the adverbial repetition test (80%), although it appears that their main focus was on timing and scope in relation to manual signs rather than exact replication of the facial expression used. One explanation is that participants in both groups may have attended to the manual signed information on the hands with more valence than the facial expressions, so in endeavouring to remember and reproduce the sentences signers focus on more faithful reproduction of manual signs at the expense of facial actions. Hietanen and Lepänen (2008) conducted experiments with congruent and incongruent information across the face and hands in sign language. They compared attention to the face and hands under different instructions. Certain emotional facial expressions attracted greater attention to the face than the hands regardless of instruction (e.g. angry and happy). In light of these findings, the effect of instructions should not be underestimated, it would be interesting to see if participants performed differently if they were specifically instructed to attend to the face over the hands during the sentence repetition task.

Additionally, the nature of the stimuli may have had a mediating effect on results, since it involved video presentation of a non-interactive model rather than live human interaction. If the sentences had been produced live, this may have resulted in greater differences between groups, as individuals with ASD may have found the task harder with

an increased communicative element (Nielsen et al., 2008). However for ease of administration and issues with standardisation the use of a video format was justified. Another methodological pitfall is that sentence repetition may have been inhibiting for children, due to being filmed and they may not have produced the full range of facial actions that they were capable of, thus true ability may not have been fully tapped. Schembri (2008) stated that observers' paradox may exist when filming deaf signers for research projects, as participants may monitor their own language output more carefully than they would naturally off camera. This self consciousness or self editing may result in a reduction in facial expressiveness.

The task also had low ceiling and working memory demands which may have masked differences between groups. It would be of interest to measure working memory and/or short term memory in both groups to see whether this influenced production of the sentences, as participants had to watch and remember the content and facial expression of each sign and then produce it back to the experimenter at the end. This may account for low facial expression production scores in both groups. Likewise in the previous chapter, participants had to memorise a narrative and retell it to the experimenter. This task required short term memory. Therefore it would be important to rule out different types of memory skill as an explanation for findings in both chapters.

Another important consideration is the lack of control condition in the current experiment. It would be interesting to compare both groups on production of meaningless facial movements to ensure they had imitation skills in general (i.e. non-linguistic information) and then see how they fare with linguistic and affective information in BSL.

Previous chapters identified impairments in the deaf ASD group with comprehending (chapter 4) and producing affective facial expressions (chapter 5). However findings from this chapter suggest that the deaf ASD group are less impaired with mimicking. They produce a comparable number of facial actions relative to controls when copying linguistic and affective facial expressions in a sentence repetition task, however their repetitions are less exact and qualitatively different from deaf controls suggesting that experience with sign language facilitates copying.

Both groups produce more linguistic than affective facial actions, the most likely explanation for this finding is that facial actions are more mandatory in linguistic sentences. For example signing a negative statement without the appropriate negative facial markers would appear strange, but signing 'THE MAN IS SAD' without a sad expression may not be idiosyncratic in the same way. Chapters 7, 8 and 9 probe facial actions in linguistic sentences more deeply, examining structures for which facial actions are more mandatory (negation, adverbials and questions).

Chapter 7: How do deaf individuals with ASD comprehend and produce facial expressions of negation in BSL?

Introduction

Findings from chapter 6 demonstrate that the deaf ASD group were comparable to controls when producing linguistic and affective facial expression targets in a sentence repetition task. However qualitative differences were found, with fewer identical repetitions in the ASD group (i.e. a greater number deviating slightly from the target facial expression). Analysis by facial expression type was not possible, as there were too few examples of each linguistic structure (e.g. negation, adverbials etc) therefore this chapter singles out negation for further investigation.

Sentences that use negation involve expressing that something is not present or is not the case. In sign language there are two ways to represent negation. The first uses a manual negative sign (e.g. NEVER, NO, NOTHING, VEE, BOO) (see Figures 7:1-7:3 for examples). Manual signs may incorporate a negative morpheme, for example positive verbs become negative (e.g. when the sign LIKE becomes DON'T LIKE and WANT becomes DON'T WANT) (see figures 7:4-7:5) (Sutton Spence & Woll, 1999). These structures are known as *negative incorporated verbs* (NIVs) (Anderson & Reilly, 1997). The second type of negation is expressed on the face as a NMM in the form of a negative facial expression (see figure 7:6). The main type of NMM for negation consists of: a) side to side head shake and b) facially expressed features such as lowered eyebrows, squinting of the eyes (Bahan, 1996), wrinkling of the nose, a downturned mouth or specific mouthings which accompany specific negation manual signs or NIVs (Sutton Spence and Woll, 1999). These NMMs may co-occur with a manual negation sign or can be produced just on the face to negate a

signed predicate. Baker and Cokely (1980) suggested that there are approximately 24 negative manual signs in ASL. There are likely to be a similar number in BSL too as both languages are comparable in their use of negation (Sutton Spence & Woll, 1999).



Figure 7:1: Example of manual sign for negation glossed NO accompanied by facial NMM of negation.



Figure 7:2: Example of manual sign for negation glossed VEE (meaning I don't have any) accompanied by facial NMM of negation



Figure 7:3: Example of manual sign for negation glossed NOTHING accompanied by facial NMM of negation



Figure 7:4: Example of manual sign NIV DON'T KNOW

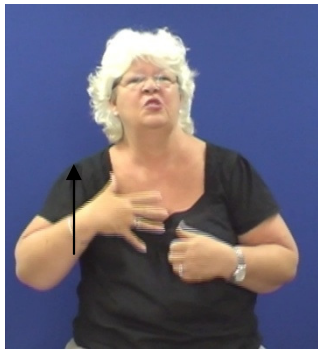


Figure 7:5: Example of manual sign NIV DON'T WANT



Figure 7:6: Manual sign HUNGRY accompanied by facial NMM of negation (no manual sign for negation)

There is debate about the status of head shake versus facially expressed components of NMMs for negation. In the majority of spoken languages head shakes are used negatively in a communicative sense, however in sign languages they have an added linguistic function. This may account for why head shakes have more valence than negative facial expressions in the non-manual marking of negation. Zeshan stated that the status of negation NMMs as grammatical “is often questionable... they tend to be less obligatory and more variable than head movements” (Zeshan 2004, p12). The head shake in negation can vary in the extent to which it is spread across a sentence, as indicated by the horizontal line in the examples below (Smith et al., 2010, p249).

_____hs

BOY MILK DRINK

‘The boy does not drink milk’

_____hs

BOY MILK DRINK

‘It was not the boy that drank milk’

Different parts of both sentences above are negated in different ways as a result of the timing and scope of the head shake.

Veinberg and Wilbur (1990) looked at manual and non-manual uses of negation in deaf native ASL signing adults in both naturalistic and elicited contexts. They found that in 82% of negative utterances adults integrated a negative head shake with a manual sign. They found supporting evidence for the use of the negative head shake in these three different contexts 1) in utterances which included negative manual signs, 2) utterances with NIV’s and 3) negative predicates. They found that NMMs do take precedence over manual signs produced by the hands, in that they can be produced without manual signs and their

meaning can still be perceived. NMMs (or facial negation) may be produced with or without a manual negation sign (Veinberg & Wilbur, 1990; Coerts, 1992; Bergman, 1995; Pfau & Quer, 2004), however manual negation signs are never produced without a negative NMM. The only exception to this would be when the face is engaged in expressions of emotion (e.g. anger, surprise). This emotional expression may then replace linguistic negation information, which is normally expressed on the face (Bahan, 1996). When a signer produces the sentence I LIKE CHOCOLATE, this signed sentence is accompanied by a negative facial expression in order to convey the meaning that the signer does not like chocolate, this is also known as a negative predicate.

Both manual and NMMs have been argued to have equivalent syntactic status (Liddell, 1980; Anderson & Reilly, 1997). Zeshan (2004) conducted the first cross-linguistic study of negation across 38 different sign languages and found that “a combination of manual and non-manual negation is probably the most common strategy cross linguistically followed by head shake only negation. They also found that manual only negation is uncommon and impossible in several sign languages” (Zeshan, 2004, p18).

One difference between negative sentences with and without manual markers is the spread of facial action (Neidle et al., 2000). Sentences with manual markers have facial actions that occur only at the onset of the production of the manual marker, whereas for sentences without manual markers they have the accompanying head shake and facial expressions for negation spread over the entire sentence (Neidle et al., 2000). The latter case is obligatory however this spreading can also be optionally present for sentences with manual markers (Sandler & Lillo-Martin, 2006).

Acquisition of negation

Sign languages hold a unique position in developmental terms. This is because deaf children acquiring a signed language must understand that facial actions are multifunctional, conveying both emotional and linguistic meaning. Spoken languages rely on the single channel of heard speech, sign languages make additional developmental demands, imposed by the hands, body and the face (Reilly, 2006). The acquisition of negation is particularly challenging, as the deaf child learns manual negative signs first, then needs to be able to differentiate between the communicative head shake for negation and the linguistic non-manual head shake, before they can be said to have full mastery. The communicative head shake is present from an early age and functions to demonstrate disagreement (Argyle, 1988; Williams, 1997). There is some evidence that this head shake is gestural and it occurs outside of language. For example infants use the head shake 'no' as a conventional gesture (Iverson et al., 2008) and great apes have been demonstrated to use head shaking to say no (Schneider et al., 2010). The linguistic head shake is produced later in development with a manual sign for negation at approximately 20-23 months and it assumes grammatical function (Anderson & Reilly, 1997). Anderson and Reilly (1997) explored the developmental sequence of negation acquisition and offered two competing hypothesis: firstly that different negation structures are acquired under a single system, which gradually differentiates between communicative and linguistic head shakes. The alternate hypothesis suggests that the linguistic system is separate to the communicative system and both forms of head shake are acquired in different stages. Two studies were conducted by Anderson and Reilly, the first was a cross-sectional study, which used naturalistic video data from 51 deaf children from the ages of 1:0-5:0 years old. A second

longitudinal study looked at data from a subset of 16 of these children. All negative utterances appearing in both data sets were analysed. Key milestones in the acquisition of negation were delineated. Typically the first use of the communicative head shake was present by 12 months of age. At 18-20 months infants were producing some basic negative manual signs (e.g. NO, DON'T WANT). By 24 months production of negative signs increased dramatically, however they were no longer produced with a head shake, making them ungrammatical. The head shake only reappeared with the production of negative manual signs a few months later, with errors in timing and scope. Complete mastery of negation didn't occur until 26-28 months, when children started to co-articulate manual and NMMs correctly to form negative sentences. These findings demonstrate that deaf children are using communicative head shakes at an early age for negation, however they are not able to use this head shake linguistically as a NMM until much later in development. Two possible conclusions emerge: firstly, communicative and linguistic systems have separate patterns of acquisition and secondly that negative manual signs are successfully acquired prior to negation NMMs. Similar acquisition patterns have also been found for other linguistic structures with manual and non-manual components for example Wh questions and conditionals (Reilly et al., 1990). There is a broad developmental disposition towards acquiring manual signs before NMMs. The finding that deaf children acquiring sign language prioritise linguistic information from hand actions and fail to attend to linguistic information expressed on the face supports this claim (Reilly & Bellugi, 1996).

Anderson and Reilly (2002) conducted another study looking at the acquisition of negation using parental report of children's use of negation. They adapted the MacArthur Children's Developmental Inventory (CDI) (Fenson et al., 1993) into an ASL version. The

CDI is a vocabulary checklist requiring parental report of comprehension and production and is completed in regular intervals during infancy (8-30 months old). Anderson and Reilly (2002) found inconsistencies between the age that parents reported their children first started using manual negation (at 12 months) and their previous experimental findings from longitudinal studies (from video recordings of deaf children and their mothers, demonstrating that manual negation emerged at 18 months) (Anderson & Reilly, 1997). This difference could be related to a number of factors such as parents' over reporting their child's ability, or the constraints imposed by the format of the CDI, not truly reflecting children's true language ability (e.g. children may have had an off day, or been conscious of the video camera, or the person filming them, especially if they were unfamiliar, which may have inhibited their sign production). In another study Mayberry and Squires (2006) reported that mastery of negation (with signs being produced incorporating the negative head shake and other NMMs) occurs by the age of 4:0 years.

A similar dissociation between communicative and linguistic head shakes is observed in hearing adult learners of sign language. McIntire and Reilly (1988) gave novice and advanced hearing learners of ASL signed sentences containing both manual and NMMs (e.g. negation, adverbials etc) and asked them to imitate them (see chapter 6 for further details of the study). Errors were made with the imitation of negation, particularly with inappropriate scope, where the negation manual marker began late or after the NMM. McIntire and Reilly (1988) hypothesised this error pattern was due to surface similarities between the linguistic role of the head shake in BSL and its communicative role in spoken languages. The timing of the head shake does not serve grammatical purpose, when it occurs with speech and no rules govern onset or offset. Consequently learners tend to make

timing errors in their production of linguistic negation markers, suggesting that head shakes with a communicative function are not reanalysed as linguistic head shakes.

The function of negation

Studies of acquisition of negation in deaf children and adult learners of sign language demonstrate that NMMs for negation are acquired differently from communicative facial expressions, suggesting a separation of function. In chapter 6 evidence demonstrating differences between affective and linguistic facial expressions in their localization and functions was reported. The two competing hypotheses regarding function of NMMs was also briefly addressed: syntactic vs. intonational. The exact role of NMMs of negation in the grammar of sign language remains controversial.

Syntactic function

Liddell (1980) strongly believed that the mandatory presence of NMMs for comprehension and their temporal relationship with manual markers confirms a syntactic role. Other proponents of the syntactic hypothesis include Wilbur and Patschke (1999) and Neidle et al., (2000). Boudreault and Mayberry (2006) conducted a study, which demonstrated that NMMs of negation have a syntactic function, using a grammatical judgment task. Different types of linguistic structures in ASL were manipulated (negation, questions, adverbials, conditionals and relative clauses) so that participants were presented with both grammatical and ungrammatical forms of each sentence type. Negation sentences were manipulated so that half of the sentences contained only negation NMMs (without the corresponding manual sign) and half used a manual sign for negation and obligatory NMMs. These sentences were made ungrammatical by separating the manual sign from the verb in the

manual sentences and separating the facial marker from the verb in the non-manual sentences. Participants had to decide whether sentences were grammatically correct or incorrect. No differences were found in accuracy judgments for negation across sentence types with facial markers and manual signs. Interestingly, negation sentences were more accurately judged in comparison to other linguistic structures. They proposed that the linguistic facial expressions for negation have a morphemic function, whereas Wh questions and relative clauses have different functions namely phrasal and clausal functions respectively.

Intonational function

The opposing view suggests that NMMs in sign language have an intonational function (Sandler & Lillo-Martin, 2006). Facial expressions in sign language convey both emotional and linguistic information and have been compared with intonation in spoken language, (Reilly et al., 1992). Sandler (1999) supported this argument, demonstrating that non-manual features tend to change at intonational phrase boundaries, she referred to this as super-articulation, where individual facial movements in sign languages combine with each other as do tones in spoken language to interpret an utterance (Nespor & Sandler, 1999). Some researchers take a compromised view: Pfau & Quer (2010) believe that different NMMs may have separate syntactic and prosodic functions, Zeshan also remains impartial “It is often difficult to decide whether a particular component of a non-manual signal has a syntactic, a pragmatic or an affective function” (Zeshan, 2004, p14).

Atkinson et al., (2003) explored negation in deaf adult signers with stroke. Participants were three left hemisphere damaged (LHD) aphasic signers and three right hemisphere damaged (RHD) signers. Hearing people with RHD are usually characterised

by impaired face processing ability and prosodic processing/intonation deficits but preserved language (Snow, 2000; Le Grand et al., 2003; Abusamra et al., 2009), whereas LHD individuals show the opposite pattern with marked language impairments often resulting in aphasia (Woods, 1983; Knecht et al., 2000). Studies of deaf signers with LHD demonstrate that language impairments are similar to those shown by hearing individuals with LHD (Poizner et al., 1987; Kegl & Poizner, 1996; Hickok et al., 2002; Atkinson et al., 2003; Campbell et al., 2007; Saito et al., 2007). Signers with RHD often have broadly preserved sign language ability with deficits in aspects of sign language that use the RH (e.g. signing space, prosody and facial expressions) (Kegl & Poizner, 1991; Atkinson et al., 2003; Atkinson et al., 2005; Pickell et al., 2005; Campbell et al., 2007). A negation test was devised with three conditions 1) a positive condition (16 signs) and two negative conditions 2) the first negative condition had both manual and NMMs of negation presented simultaneously (manual negation, 16 signs) (e.g. BREAD NOTHING with the manual sign for NOTHING in addition to NMMs of negation) and 3) the other condition had NMMs of negation presented alone (face negation, 16 signs) (e.g. BREAD head shake and negative facial actions with no manual signs for negation). Participants had to match the signs that the experimenter produced in all conditions to one of two pictures, which reflected a negative or positive condition (e.g. a picture of a man with bread and a picture of the same man without bread). The testing of deaf lesioned individuals allowed a unique test of the competing hypothesis (namely whether negation has a syntactic function stemming from the LH or whether it has a prosodic/intonational function, which resides in the RH). If LHD individuals have difficulty comprehending NMMs of negation, this would suggest that negation has more of a syntactic function and is similar in function to other NMMs, which

are processed in the LH (Kegl & Poizner, 1996). However if RHD individuals had impaired comprehension of NMMs of negation, this would suggest they are unique from other NMMs and they have more of a prosodic function. Additional measures of face processing, speech reading, non-verbal ability and sign language production and comprehension were also taken to ensure participants were not blind to faces in general and to rule out other factors that could account for the results (e.g. low intelligence etc). The RHD signers were found to be impaired at comprehending negation in the NMM alone condition, however when the manual marker was present they were able to comprehend negation normally. LHD signers were able to perform relatively normally in both negation conditions despite displaying severe aphasia, this finding suggests negation may operate outside the traditional LH language centres. The RHD group had unimpaired general language function with face processing deficits, but no face blindness or speech-reading difficulties, however by contrast the LHD group was grossly impaired on all language tasks with the exception of negation. The authors suggest that negation should be considered broadly prosodic/intonational in function rather than purely linguistic, concluding that negation NMMs may be localised in the RH.

The study of deaf individuals with ASD also informs the debate. In the previous chapter references were made to similarities between hearing individuals with ASD and individuals with RHD. Several studies have demonstrated prosodic speech disturbances in hearing individuals with ASD, these consist of monotone intonation (speech with narrow pitch range), rate of speech being too fast, frequencies which are too narrow or too wide and poor volume modulation (Tager Flusberg, 1981; Baltaxe & Guthrie, 1987; Klin et al., 2005; Peppe et al., 2006; Hubbard & Trauner, 2007). Therefore (assuming that deaf

children with ASD are like hearing individuals with ASD) if negation has an intonational function, deaf children with ASD may be expected to have impairments when comprehending negation on the face alone in line with the RHD signers in Atkinson et al.,’s study. However as Atkinson recruited deaf adults and the current participants are children both groups may not compare.

Research looking at negation in ASD signers is sparse, a group of researchers investigated the acquisition of negation in a hearing individual with a form of ASD (Polyglot savant) (Morgan et al., 2007; Smith et al., 2010). “Christopher” was compared to a control group of 40 other hearing BSL learners who had been learning BSL for the same length of time and had the same number of hours of instruction. Findings from a comprehension of negatives test and a grammaticality judgment task demonstrated that Christopher used negation appropriately in conversation and mirrored controls with comparable performance but he showed subtle, qualitative difficulties in combining the use of manual signs and NMMs and he used little facial expression in his production of negation BSL sentences (see Chapter 1 literature review for further details).

Experiment 5a: The test of BSL negation comprehension in deaf individuals with ASD and typically developing deaf controls

Hypothesis

On the basis of the findings demonstrating that hearing children with ASD have impairments in intonation (Tager Flusberg, 1981; Baltaxe & Guthrie, 1987; Klin et al., 2005; Peppe et al., 2006; Hubbard & Trauner, 2007) and that negation in sign language functions like intonation (Atkinson et al., 2003). It is predicted that *the deaf ASD group will be impaired relative to deaf controls (in accuracy and speed) at comprehending negation.* In keeping with the acquisition data (Anderson & Reilly, 1997), *both groups are expected to have more difficulty in the condition where negation is on the face alone compared with manual negation (which is on both the hands and face).*

Methodology

Participants

Deaf ASD group (n=13) and deaf control group (n=12) (see chapter 2 for group matching characteristics).

Materials

The test of BSL negation comprehension developed by Atkinson, Campbell et al., (2003) was adapted for the current study. The test is particularly suited to research with children with ASD due to a simple format with pictures on paper and an experimenter signing the signs in real time. However some modifications to content were made to increase age appropriateness (e.g. items such as: pop champagne, pipe and married were removed and replaced with hair, sleep and throw etc), these newer items were added using ClipArt

software (www.clipart.com) and Adobe Photoshop. Nine items from the original test were retained and six new items were added to complete a set of 15 pairs of pictures.



Figure 7:7: Example of response pair positive: negative

Each pair depicted a positive and negative version of the same scenario (e.g. BREAD or BREAD NOTHING see Figure 7:7). The participant was asked to watch one of three possible target video-clips for each picture pair 1) positive signs, 2) face negation and 3) manual negation (the manual negation condition consisted of negation information on the face as well as on the hands through the manual sign NOTHING). Participants responded by selecting a letter on the keypad to indicate their choice. During the test each participant saw each of the 15 picture response pairs three times with variation in the type of target statements ($n=15$ in each condition). Eleven positive items created a control condition which served to balance out the number of positive and negative signs in the experiment. These items differed slightly to the other positive items, as there was no element of negation in the pictures. In these control items participants had to pick between two different images after they saw a sign (e.g. after seeing SHOES, see Figure 7:8, they had to choose between a picture of a pair of socks and a picture of some shoes). (These control

trials were also useful in order to ensure participants understood task instructions and could respond accurately in conditions without negation).



Figure 7:8: SHOES



Figure 7:9: BREAD (positive)



Figure 7:10: BREAD face negation



Figure 7:11: BREAD NOTHING manual negation

Another adaptation to the methodology of the original test was the addition of a vocabulary check prior to the test. Participants were shown all pictures for naming to ensure that they knew the sign. Where participants used a different sign to the one that was in the test, they were familiarised with the test version. Different pictures were used for the objects in the vocabulary check and the experiment, to minimise priming. The paper based test was also adapted for administration as a computerised test, allowing more precise measurement of reaction time. The bespoke experimental software was developed with technical support from Michael Coleman at the department of human communication science. The experiment consisted of 59 trials (3 practice and 56 test trials). On each trial a video-clip of 2-4 seconds long was presented to participants. The video-clips were presented by a deaf native signer. There were 27 positive trials, 11 of these were control trials and there were 32 negative trials in total, 16 face negation trials and 16 manual negation trials. In the three different conditions the 16 items were the same, however they were differentiated by their positive or negative state, for example two pictures depicted either a man cutting bread, or a man with an empty plate and a knife (see Figure 7:7), there were three signed conditions which accompanied this response pair 1) bread positive (see Figure 7:9), 2) bread face negation (see Figure 7:10) and 3) bread manual negation (see Figure 7:11). The order of the

trials was randomised, however a programming rule ensured that no more than two of the items within the same condition were presented in successive order.

Procedure

A vocabulary check preceded the experiment to ensure familiarity with signs used in the test. Participants were presented with the experimental software on a laptop computer. Each video-clip showed a male native presenter signing a one or two sign pictureable statement in either the positive or negative conditions. After the video-clip was played a screen was presented with the response pictures side by side, both were 400x400 pixels in size.

Participants pressed a button on the keyboard in order to indicate whether it was the picture on the left (Z) or the picture on the right (M) that matched what was signed in the video-clip. The location of the correct answer was counterbalanced so the correct response appeared equally often on each side. The pictures remained on the screen until participants indicated their answer by pressing the relevant button on the keyboard. If after six seconds participants had not made a response, the screen went blank in order for the next trial to begin and the trials that were then subsequently missed were repeated at the end of the experiment. After each trial participants had to press the space bar to continue on with the next trial. Three practice trials consisted of one positive trial, one negative trial using facial negation and one negative trial using manual negation. The practice trials were repeated if necessary or until the task was clearly understood.

Results

The positive trials were included to ensure that participants could comprehend the task. Non-parametric Mann Whitney tests were carried out for accuracy scores and reaction time for both groups on the positive condition. There were no significant differences between

groups ($U(25)=.59.5$, $p>.05$) for accuracy scores (Median: ASD: 96%, control: 100%), or reaction time ($U(25)=.73$, $p>.05$) (Median: ASD: 1954 milliseconds (ms), control: 1649.3 ms) indicating that the task was well understood.

For the two negation conditions a Kruskal-Wallis non-parametric one way analysis of variance was applied to both groups for each condition separately. No significant differences between the groups were found on the face negation condition ($H=.061$, 1df, $p=.81$) or for the manual negation condition ($H=1.3$, 1df, $p=.25$). Participants in both groups showed a similar pattern of results: (face negation: Median: ASD: 93%, control: 89.9%, manual negation: ASD: 93%, control: 92.9%). Figure 7:12 shows that the deaf ASD group had marginally higher accuracy scores than the deaf controls, however this finding was non-significant.

The Wilcoxon sign test was calculated for each group separately to compare whether there were significant differences in performance on manual and face negation conditions. For the deaf ASD group there was a significant difference between manual and face negation conditions ($Z= -2.2$ $p<.05$), there was no difference between these two conditions for controls ($Z=-1.6$, $p>.05$). The deaf ASD group surprisingly showed better performance in the face negation condition than the manual negation condition relative to controls.

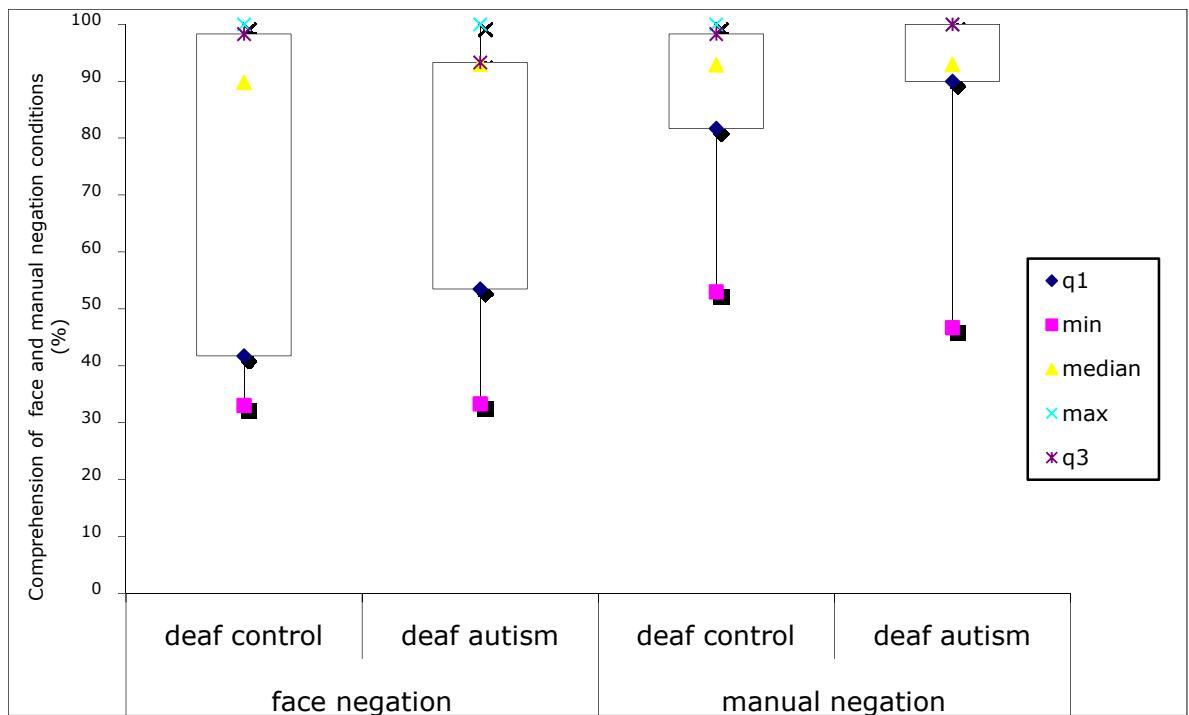


Figure 7:12: Box plot illustrating the comprehension of face vs. manual negation in the deaf ASD and control groups

Reaction time scores were also analysed using a Kruskal-Wallis non-parametric one way analysis of variance. There were no differences between groups in reaction time for face negation ($H=.047$, $1df$, $p=.83$) or manual negation ($H=1.45$, $1df$, $p=.703$). Figure 7:13 shows comparable reaction times between groups across both conditions: (face negation: Median: ASD: 2526.5 ms, control: 2061.8 ms, manual negation: ASD: 2288.1 ms, control: 1888.1 ms).

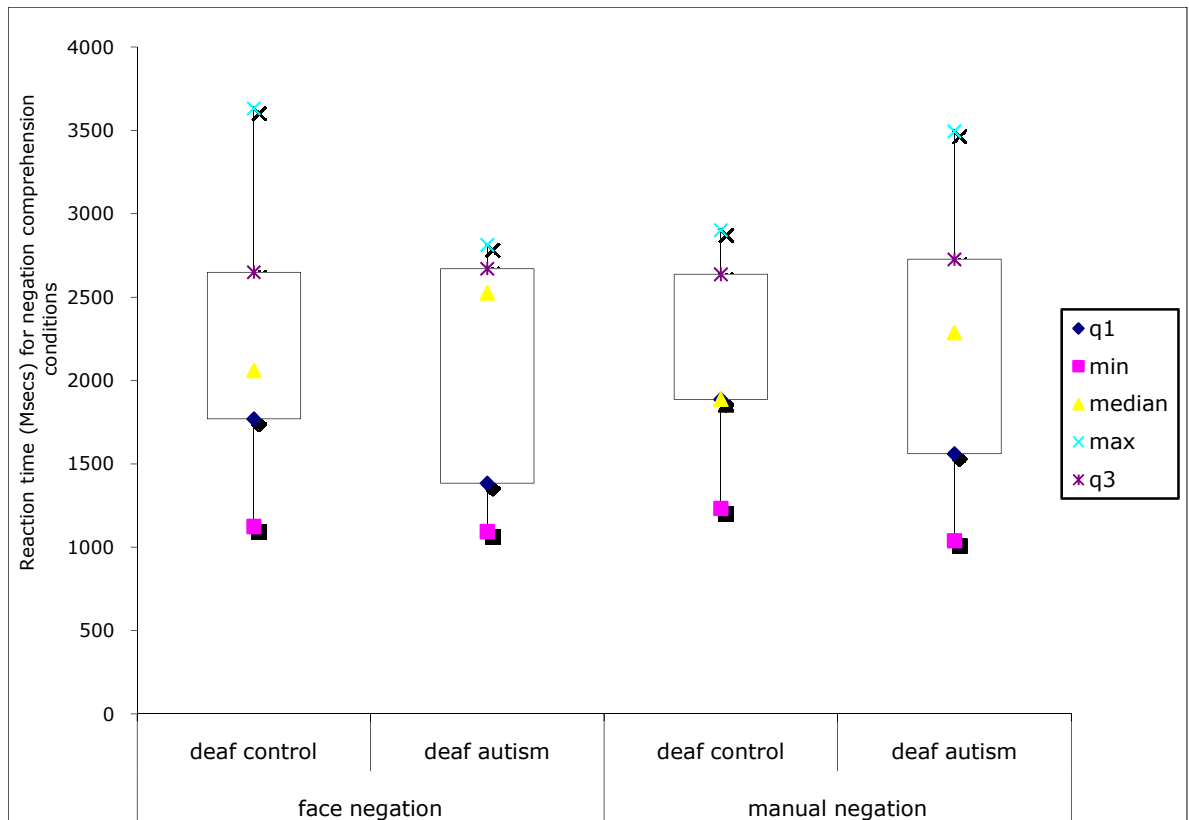


Figure 7:13: Box plot illustrating the reaction time scores for face vs. manual negation in the deaf ASD and control groups

Discussion

The current study found no impairment with negation in the deaf ASD group. They performed on a par with controls for manual negation and showed better accuracy even for negation that is solely expressed by the face. There were no differences between groups for reaction time on these two conditions. The hypothesis that the deaf ASD group would be poorer at comprehending negation was therefore not supported. The findings were inconsistent with the hypothesis that participants would be significantly better with manual than face negation.

These findings were not in line with Atkinson's study, as they found greater discrepancy between performance on comprehension of face negation relative to manual negation in the right hemisphere deaf group compared to the left hemisphere group. The difference in findings between the two experiments may suggest that there is a difference between acquired and developmental groups in relation to negation in the face, more research would need to be done on both groups using broader measures to establish whether or not this is valid. Alternative explanations could also account for differences in findings. Atkinson's task was a lot easier, as LHD aphasics were able to follow the task, it also involved using live signing rather than a video clip of a native signer. In the current experiment participants in both groups had comparably high scores for both conditions approaching ceiling level for the manual negation condition. A harder task may need to be developed that results in lower scores, this may show differences between groups. The age difference between the participants in the current experiment and the older stroke patients in Atkinson's study may also account for differences in findings.

Atkinson's study demonstrated support for the intonational role of negation NMMs, as RHD deaf signers were unable to comprehend negation on the face alone (as intonation is located in the RH in deaf signers (Hickock et al., 1998)). The current study does not lend support to the intonational function of negation NMMs as individuals with ASD who are known to have impaired intonation skills (McCann & Peppe, 2003; Peppe et al., 2006) (and who are deaf) did not show deficits with comprehending negation on the face alone. Further tests of intonation ability should be given to the deaf ASD group in order to determine whether they are in fact like their hearing counterparts impaired with intonation before making conclusions regarding negation and the syntactic/intonational hypothesis.

The deaf ASD group may have been unimpaired with the comprehension of negation because the form used was quite salient (e.g. a large dramatic head turn from side to side). Future research with more subtle productions of negation could be carried out to further investigate this possibility. Nevertheless these findings are exciting in that they reveal that deaf individuals with ASD have wholly preserved comprehension of negation on the face in BSL.

Experiment 5b: The test of BSL negation comprehension-masked

To explore whether findings from experiment 5a could be explained by participants using non-facial strategies to detect negation (e.g. head shake rather than facial actions) or whether the paradigm was not difficult enough to demonstrate group differences. A further experiment was conducted using identical methodology with an additional masking manipulation. In experiment 5b participants completed the BSL negation test under 3 masking conditions 1) face 2) head and 3) hands. This adaptation made the test harder and may lead to more subtle differences between groups being revealed. It was predicted that performance of the deaf ASD group and control group would be differently affected by masking of the face, head and hands.

Grossman and Tager-Flusberg (2008) conducted an experiment looking at masking of facial speech and emotional expressions in hearing adolescents with ASD and typically developing controls (see chapter 4 for more details). A significant difference was found for controls for masked and unmasked faces, with greater accuracy in the unmasked condition, whereas individuals with ASD had no difference between conditions. Several experiments (Reilly et al., 1992; Hietanen & Leppanen, 2008) have been conducted using masking of the face in sign language (see chapter 4 for further details). In chapter 4 the deaf ASD and

control groups were tested on their recognition of affective facial expressions in masked and unmasked conditions. Both groups showed a significant effect of masking where they produced lower scores in the masked face condition compared to the unmasked condition however the deaf ASD group had a significantly smaller difference between scores in both conditions relative to controls. These findings suggest that masking of the face is not detrimental to the comprehension of affective facial expressions for individuals with ASD.

Performance when facial cues and head shake are masked may reveal how reliant deaf signers are on the face to comprehend negation and how efficient they are at comprehending negation from the hands alone. Alternatively manual cues obscured through masking of the hands, will demonstrate how participants fare when they have to comprehend negation from the face alone. Participants with ASD, who are hypothesised to show less reliance on facial information than controls, may show greater difficulty with comprehension in a manual masking condition compared to facial masking in which they might be expected to perform on a par with or better than matched controls.

Hypothesis:

In experiment 5b specific effects are expected depending on the negation condition and the body parts that are masked. For example:

- 1) For stimuli showing face negation and manual negation it is expected that *deaf controls will have lower comprehension scores when the head is fully obscured compared to when only the face is masked, as the head shake will reveal important information about the negative status of the sign.* In line with Grossman and Tager-Flusberg (2008) and the findings from chapter 4, *it is expected that the deaf ASD*

group will be less impaired compared to controls when comprehending negation in conditions where the face is obscured (HEAD masked, FACE masked).

- 2) *For face negation stimuli it is expected that masking of the head and face (HEAD masked, FACE masked) will lead to impaired comprehension of negation (accuracy and speed) for deaf controls relative to manual negation stimuli.*
- 3) *For manual negation stimuli it is expected that the deaf ASD group will have reduced comprehension scores and be slower in the HANDS masked condition relative to controls, as they will be forced to attend to the face to comprehend negation.*

Methodology

Participants

Ten deaf children with ASD and 12 typically developing deaf controls completed experiment 5b (see chapter 2 for group matching characteristics). The data from three deaf individuals with ASD was excluded, as they either scored at floor or could not complete the test due to the greater number of trials and added length of the task.

Materials

In the masked condition, video-clips from the test of BSL negation comprehension were presented to participants with 1) the face, 2) head or 3) hands obscured. Motion 4 (a package that is a part of the final cut pro software on an apple Mac computer) allowed masking templates to be created and placed over the signer in each video-clip. Some items from the original test were excluded as they consisted of signs where the hands made

contact with or were close to the head and face which meant that the hands and face could not be independently obscured (e.g. SLEEP, HAIR etc see Figure 7:14).



Figure 7:14: SLEEP and HAIR

The original set of 15 items for each condition 1) positive 2) face negation and 3) manual negation were reduced to eight for each group. In addition to the three negation conditions in the stimuli set, there were a further three conditions related to level of masking of each of the video-clips: a) HEAD masked (see Figure 7:15) where the head shake and negative facial actions could not be seen, b) FACE masked (see Figure 7:16) where only the face was obscured and the head remained visible meaning that negative facial actions were masked but the head shake could still be seen and c) HANDS masked (see Figure 7:17) in which the hands were masked so that manual signs were not visible but negation facial actions and head shake could be seen. Each of the eight items were produced in three different negation conditions and three different masking conditions. For example the item bread had trials 1) for bread positive in each of the three masking conditions: a) HEAD masked, b) FACE masked, c) HANDS masked 2) bread manual negation in each of the three masking conditions: a) HEAD masked, b) FACE masked, c) HANDS masked and 3)

bread face negation: a) HEAD masked, b) FACE masked, c) HANDS masked. Altogether there were 72 test items and 8 practice items (see Appendix 4 for list of items).



Figure 7:15: The HEAD masked negation condition



Figure 7:16: The FACE masked negation condition

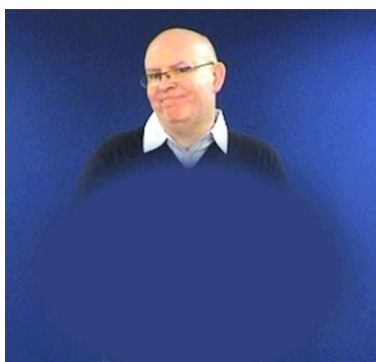


Figure 7:17: The HANDS masked negation condition

Procedure

The procedure was identical to experiment 5a except that participants were informed that the signer in the video-clips would have his whole face, parts of his face or his hands masked so that they could not be seen. Participants were instructed to match one of the two pictures to the signed video-clip. Testing took place a minimum of 2 weeks after testing for experiment 5a. Practice trials incorporated trials from experiment 5a in order to ensure the task was understood. Participants were given a short break in the middle of the task due to the length of the task, after 40 trials a computerised message appeared in the computer program instructing participants to have a break and to press the space bar when they felt ready to continue with the task. Accuracy and reaction time were recorded.

Results

For the negation stimuli, participants in both groups had lowest comprehension scores when the HEAD was masked. This was true for both negation expressed by the face alone (Median: ASD: 12.5%, control: 12.5%) and manual negation (Median: ASD: 87.5%, control: 100%) when only the FACE was obscured and the head remained visible scores increased: face negation (Median: ASD: 50%, control: 56.3%) manual negation (Median: ASD: 100%, control: 100%) suggesting that the head shake is critical in detecting negation when the face is obscured. Where both manual signs and a head shake were visible accuracy increased to 100% suggesting that processing facial action is not mandatory except where negatives have no manual component and are purely expressed by the face and head shake. Figure 7:18 shows that participants in both groups had comparable results for each masking condition in the face negation and manual negation conditions.

In order to test hypothesis 1, which stated that masking of the HEAD would lead to greater impairments than masking of the FACE for deaf controls, a Kruskal-Wallis non-parametric one way analysis of variance was applied to test differences between groups in both: HEAD and FACE masked conditions. Despite median differences, no significant differences between groups were found for either condition on both facially expressed and manual negation. For face negation there was no significant difference between groups for HEAD masked ($H=.843$, 1df, $p=.36$) and for FACE masked conditions ($H=.77$, 1df, $p=.38$). For manual negation there was no significant difference between groups for HEAD masked ($H=.95$, 1df, $p=.33$) or FACE masked conditions ($H=.52$, 1df, $p=.47$).

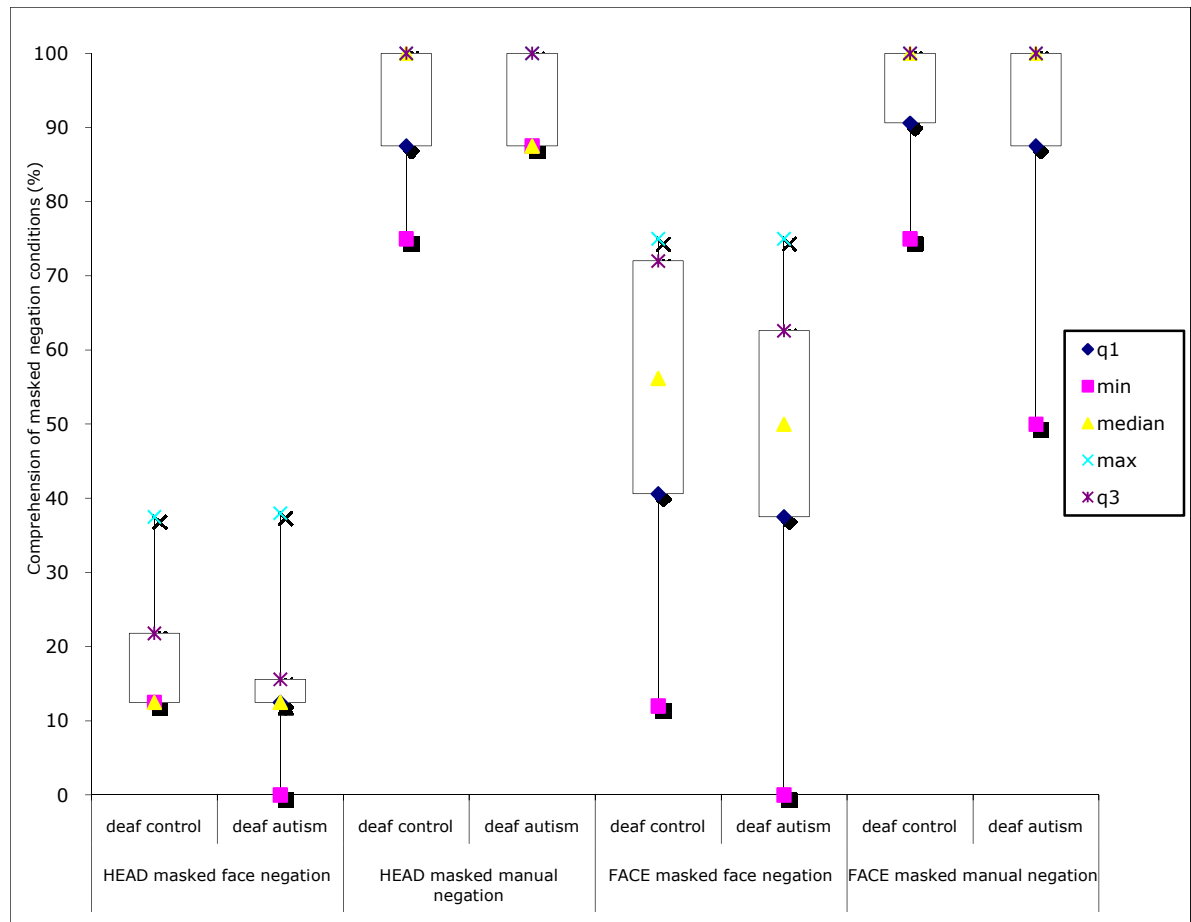


Figure 7:18: Box plot illustrating the comprehension of HEAD and FACE masking in face and manual negation conditions

No significant differences in reaction times were found using a Kruskal Wallis non-parametric one way analysis of variance for each condition for both groups. For face negation there was no difference between groups for HEAD masked ($H=.00$, 1df, $p=1$) and FACE masked conditions ($H=.08$, 1df, $p=.77$). For manual negation there was no difference between groups for HEAD masked ($H=1.7$, 1df, $p=.18$) and FACE masked conditions ($H=1.1$, 1df, $P=.29$).

Figure 7:19 below illustrates slower comprehension times for facially expressed negatives when the HEAD was obscured, across both participant groups (Median: ASD: 1606 ms,

control: 1642 ms). Followed by the FACE masked condition (Median: ASD: 1283 ms, control: 1464 ms), which was not significant.

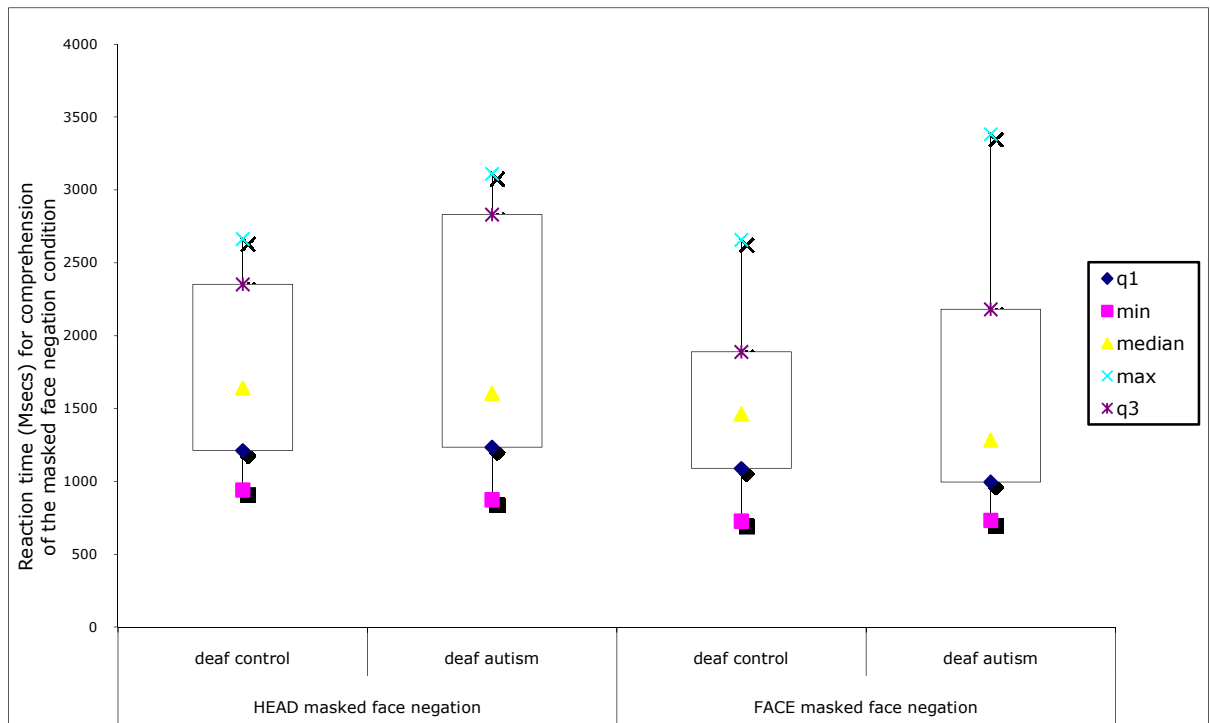


Figure 7:19: Box plots illustrating reaction time scores for comprehension of the face negation condition over different levels of masking

For hypothesis 2, which states that participants would have impaired comprehension of negation under masking conditions in the face negation condition relative to the manual negation condition, the Wilcoxon sign test was calculated for each group comparing performance in the face negation condition and manual negation condition when the HEAD or the FACE were masked. For the ASD group there was a significant difference between groups in accuracy for HEAD masking in both negation conditions ($Z=-2.8$, $p<.05$) and for FACE masking in both conditions ($Z=-2.9$, $p<.05$). For deaf controls there was also a

significant difference in accuracy scores for HEAD masking in both conditions ($Z=-3.1$, $p<.05$) and for FACE masking ($Z=03.06$, $p<.05$) (see Figure 7:18). These findings suggest that both groups have comparable scores with significant differences between these two conditions, the differences between these conditions reflect the greater difficulty of the HEAD masked condition relative to the FACE condition for both groups.

To explore whether the deaf ASD group were significantly impaired relative to controls on the manual negation condition (hypothesis 3) a Mann Whitney test was calculated for accuracy scores for manual negation in the HANDS masked condition. No differences between groups were found ($U(22)=44$, $p>.05$). The deaf ASD group had lower scores (Median: ASD: 87.5%, control: 93.8%) however this trend was non-significant. Reaction time scores were also compared and no differences were found between groups ($U(22)=53$, $p>.05$) (Median: ASD: 1809 ms, control: 1873 ms).

In order to rule out guessing strategies resulting in chance level responding, one sample t-tests were calculated on the basis of participants in either group scoring at a 0.5 (1/2) level of chance. Both groups scored significantly above chance level on for both negation types (face negation, manual negation) and levels of masking (HEAD, FACE, HANDS) (see Table 7:1).

Condition	Deaf ASD	Deaf control
Face negation, HANDS masked	t(9) =10.8, p<.001	t(11)=24.0, p<.001
Face negation, FACE masked	t(9)=3.8, p<.001	t(11)=9.9, p<.001
Face negation, HEAD masked	t(9)=3.8, p<.05	t(11)=6.0, p<.001
Manual negation, HANDS masked	t(9)=11.1, p<.001	t(11)=32.5, p<.001
Manual negation, FACE masked	t(9)=18.4, p<.001	t(11)=40.6, p<.001
Manual negation, HEAD masked	t(9)=45.1, p<.001	t(11)=39.2, p<.001

Table 7:1: Significance levels (above chance) per group for each condition

Discussion

No significant differences were found between the deaf ASD and control groups in their comprehension of negatives under conditions of facial and manual marking. These findings build upon those of experiments 5a and 5b which showed that deaf children with ASD perform on a par to their typically developing peers in the comprehension of facial negation. Both groups performed similarly across negation and masking conditions. This finding is not in line with hypothesis 1 which predicted that deaf controls would be more impaired with facial masking relative to the deaf ASD group because the latter were thought to be less reliant on facial information. Instead the results show for facially expressed negation, the performance of both groups was suppressed when the face and head shake were obscured compared to when the face alone was masked. Both groups showed a significant difference between face negation and manual negation when the HEAD and

FACE were masked. This finding is on a par with hypothesis 2, however once more it was not expected that the deaf ASD group would produce this finding along with the deaf controls. Hypothesis 3 was not supported, as groups performed equally well when the hands were masked suggesting that deaf individuals with ASD do not rely on the hands to a greater extent than deaf controls.

The fact that different types of masking were not more detrimental to either participant group is inconsistent with Grossman and Tager-Flusberg's (2008) findings and the findings from chapter 4 in this thesis, as both of these studies showed that there was a difference between hearing individuals with and without ASD in their comprehension of masked and unmasked faces. This difference may have occurred due to the fact that the current experiment used linguistic facial expressions and the other experiments used affective facial expressions.

Participants in both groups had lower scores for conditions where the face and head were obscured, despite this scores were not at floor and participants' were still able to comprehend some negation sentences without being able to see the face or head shake. This may be due to subtle differences between the different conditions in the videos. The video-clips for the face negation condition were slightly different to the video-clips for the masked negation condition, as the manual (non-negative) sign was held for longer with the accompanying negative facial actions in the face negation condition. These subtle differences may have helped decoding with minimal information from the hands and body.

Findings from the current experiment demonstrate that when the negation comprehension task is made harder by selectively masking components of the face, head and hands, participants in both groups still perform comparably. This suggests that both

groups use the face, head and hands in similar ways when comprehending negation, as they showed no differential patterns of impairment.

In summary, tests of negation comprehension went against expectations revealing no significant impairment in understanding facial expressions of negation by the deaf ASD group. Turning now to production, the ability to produce facial expressions of negation will be explored to see if this ability is also preserved.

Experiment 5c: Negation Production test

Hypothesis:

In light of the findings of experiment 5a and 5b with no differences between groups for the comprehension of negation, it is expected that the *deaf ASD group will produce a comparable number (quantity) of facial expressions of negation to controls.*

Methodology

Participants

The same participants from experiment 5a were recruited.

Materials

Participants were presented with the A4 paper copies of images from the original negation task. Thirty six of the images from the original negation task were used, as the dummy items from experiment 5a were removed (e.g. SHOES with a picture of shoes and socks) leaving 18 trials (with a pair of pictures in each trial).

Procedure

Participants were presented with pictures and were asked to describe them. The images were presented in pairs with the positive image always being presented first and the negative image second (e.g. picture of a man with an apple first, followed by a picture of the same man without the apple second (see Figure 7:20 below)).



Figure 7:20: Example of pair of pictures used in the negation production test

For the first set of pictures the experimenter demonstrated how to sign the descriptions of the pictures to the participant, by presenting them with two pictures and signing the positive followed by the negative (e.g. APPLE HAVE, APPLE NOTHING). The signs that the experimenter produced demonstrated clear facial expressions and head shakes for negation. For the next set of pictures the experimenter then asked the participant to look at the pictures (positive followed by negative). If participants did not respond appropriately by producing the positive followed by the negative, the experimenter would prompt them by pointing at both pictures and asking them what was different about the second picture or giving them another example until they understood the nature of the task. Each participant was presented with the images in the same order, they were filmed for the duration of the task so their negation facial expressions could be coded at a later date. Participants were given the production test separately to the BSL test of negation comprehension and the

masked version, all three tests were given on different testing occasions, which were at least 2 weeks apart.

Coding system

The negation production task was given to two deaf adult native signers in order to measure how they produced facial expressions of negation. The video-clips of the deaf adult native signers were used in order to develop a coding system, which measures the target responses for each negative picture. The coding system used for facial expressions of negation, differs from that used in previous chapters. This is because observations of the video-clips of the deaf adult native signers showed that facial actions for negation are largely consistent over different trials, unlike affective facial expressions where different facial actions were produced for different emotions in previous production tests. Three features emerged as being fundamental in correct negation productions: negative head shake, furrowed eyebrows and downturned/pursed lips. These three facial actions were then used to code the facial expressions for negation in participants' sign productions. The video-clips for each participant were edited and analysed using ELAN. Each video-clip in ELAN was paired with a template that had 7 tiers: 1) was the sign produced positive or negative (this was coded as P or N), 2) was negation present in the sign? (e.g. for positive items this was scored as N/A for negative items without negation present this was scored as N (no) and for those with negation this was scored as Y (yes)). Responses for positive pictures were not coded. The remaining four tiers were only scored for negative items, 3) was there a head shake? This was scored as 0 or 1 depending on whether the negative head shake was present or not, 4) were the eyebrows produced correctly? This was scored as 0 or 1 depending on whether or not they were active during the negation, 5) were the lips

produced correctly? When lips were pursed or downturned this was scored as 1, if there was no lip movement or something different was produced on the mouth this was scored as 0 and 6) what was the total score? This allowed the total value for facial expression targets for negation to be scored per item. A maximum total score would be 3 where a negative facial expression featured furrowed eyebrows, a head shake and downturned/pursed lips, if only two of the three negative facial actions were present then a score of 2 would be given and so on. (See Appendix 5 for coding target sheet). For participants who produced no facial expression targets for negation on the negative items, they received a score of 0. Another tier was created to represent quality of negation facial expressions produced: 7) facial actions were coded as identical, similar, miscellaneous and blank (as in chapters 5 and 6). Once coding was done for each participant, annotation statistics were exported from ELAN into Excel and then converted into SPSS files.

Results

For each participant a percentage of overall negation facial actions produced were calculated by working out the number of targets that each participant had produced from a total maximum score, which was based on the two deaf adult native signers' productions. Some participants signed some of the negative items as positives (e.g. instead of signing NO FEED after signing the picture baby feed, they signed BABY SIT DOWN). Positives were not coded in the current task, as with experiments 5a and 5b. Therefore not every participant produced the same number of negative signs and facial expressions. To account for this difference each participant's score was compared to a maximum score that was produced by the deaf native signers (e.g. 3) for each trial they did.

A non-parametric Mann Whitney test was carried out comparing quantity of negation facial actions that were produced for both groups. No significant differences were found between groups ($U(25)=46, p>.05$). Figure 7:21 shows that both groups produce a comparable number of negation facial actions (Median: ASD: 38.1%, control: 51.1%).

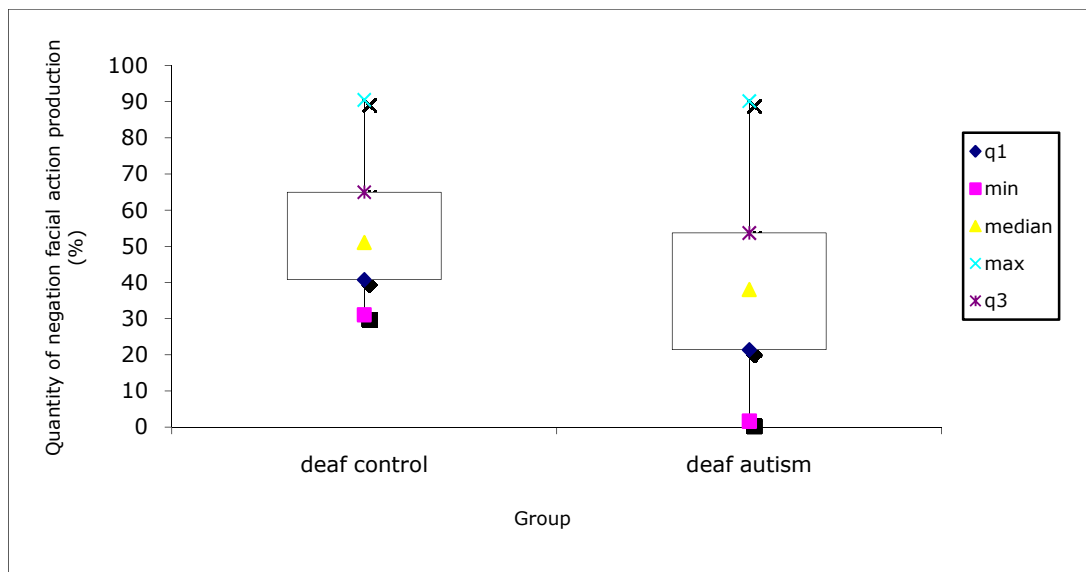


Figure 7:21: Box plot illustrating the quantity of negation facial actions produced by both groups

Both groups were compared on their range of negation facial action scores (from 0-3) using non-parametric Mann Whitney tests, no significant differences were found between groups for either score. Figure 7:22 illustrates how both groups compared in production of negation facial actions.

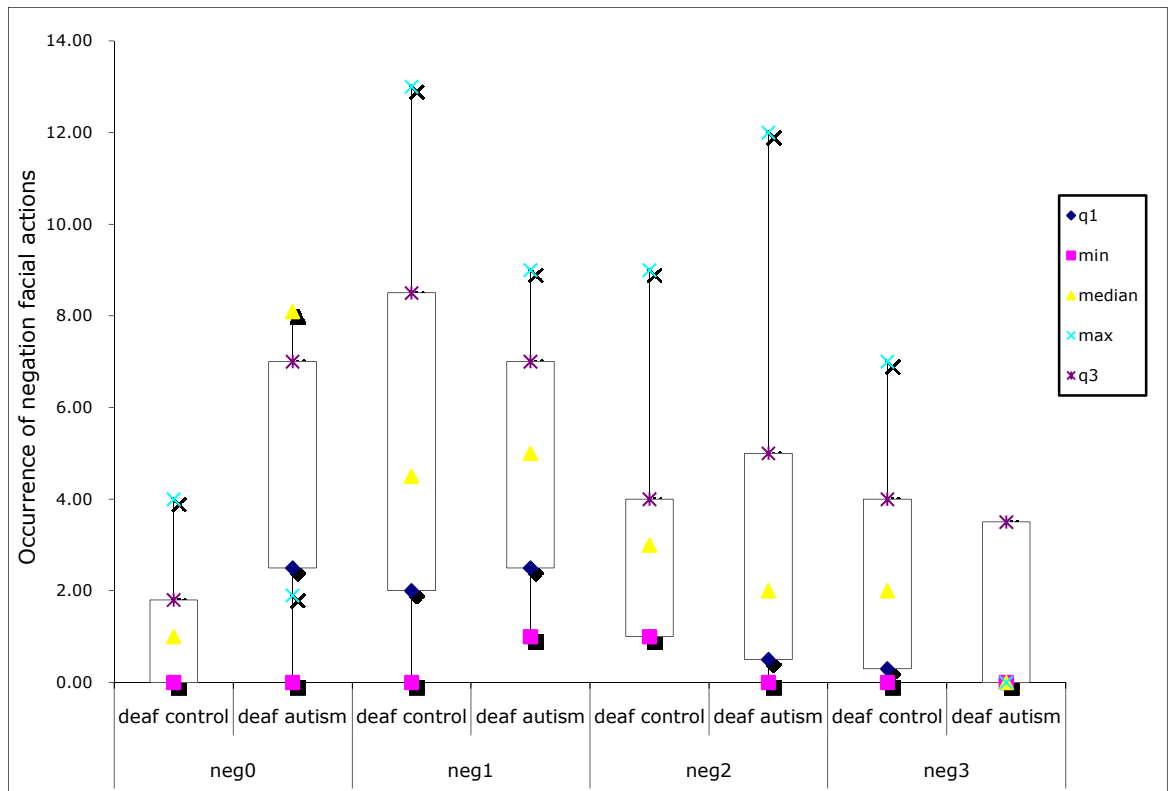


Figure 7:22: Box plot illustrating the occurrence of negation facial action scores for both groups

The same five participants (that were coded by the second rater in chapters 5 and 6) were coded by the second rater (using blind rating) on the negation production test. The intraclass correlation between the raters was .968.

Quality of negation facial actions produced between groups was compared using Mann Whitney tests on blank and non-blank (identical, similar and miscellaneous) facial expressions for both groups. No significant differences were found in the proportion of blank and non-blank facial negation expressions across all conditions (see Figure 7:23).

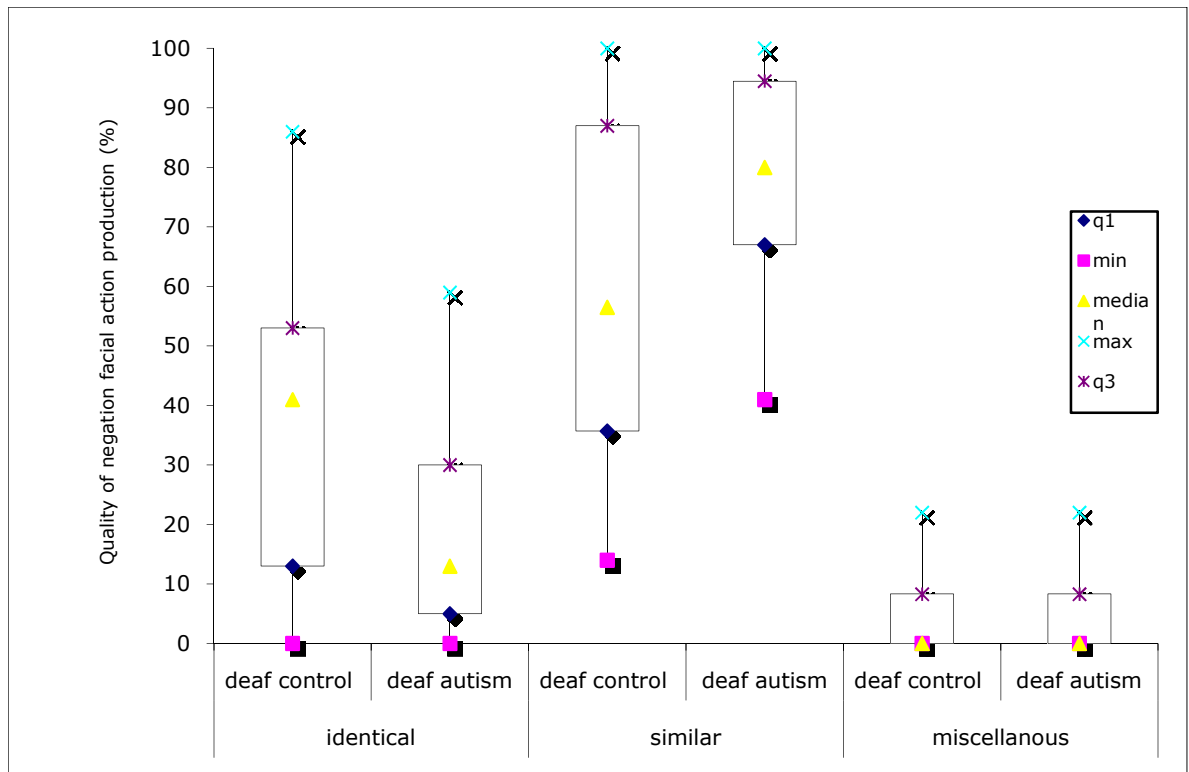


Figure 7:23: Box plot illustrating the quality of negation facial actions produced across groups

The coding of negation required three facial actions to complete each negative production, with 1 mark each given for the presence of: head shake, furrowed eyebrows and downturned/pursed lips. As well as item scores, scores were calculated for individual negation facial actions across the whole test giving a total score for head shake, eyebrows and lips. This score was expressed as the percentage of time this feature was present across their total number of productions. A Kruskal-Wallis non-parametric one way analysis of variance was calculated for both groups on each parameter. There was no difference between groups for head shake ($H=.007$, $1df$, $p=.94$) and for eyebrows ($H=.29$, $1df$, $p=.58$), however both groups differed in the emphasis placed on the lips in negation expression ($H=6.2$, $1df$, $p<.05$). Figure 7:24 shows that both groups used head shake the most (Median:

ASD: 83.3%, control: 80.6%), but the control group used the lips as a facial action most often after head shake (Median: ASD: 14.3%, control: 54.7%) and eyebrows the least (Median: ASD: 18.8%, control: 33.6%) whereas the deaf ASD group used eyebrows most then head shake and then the lips the least in their production of negation facial actions.

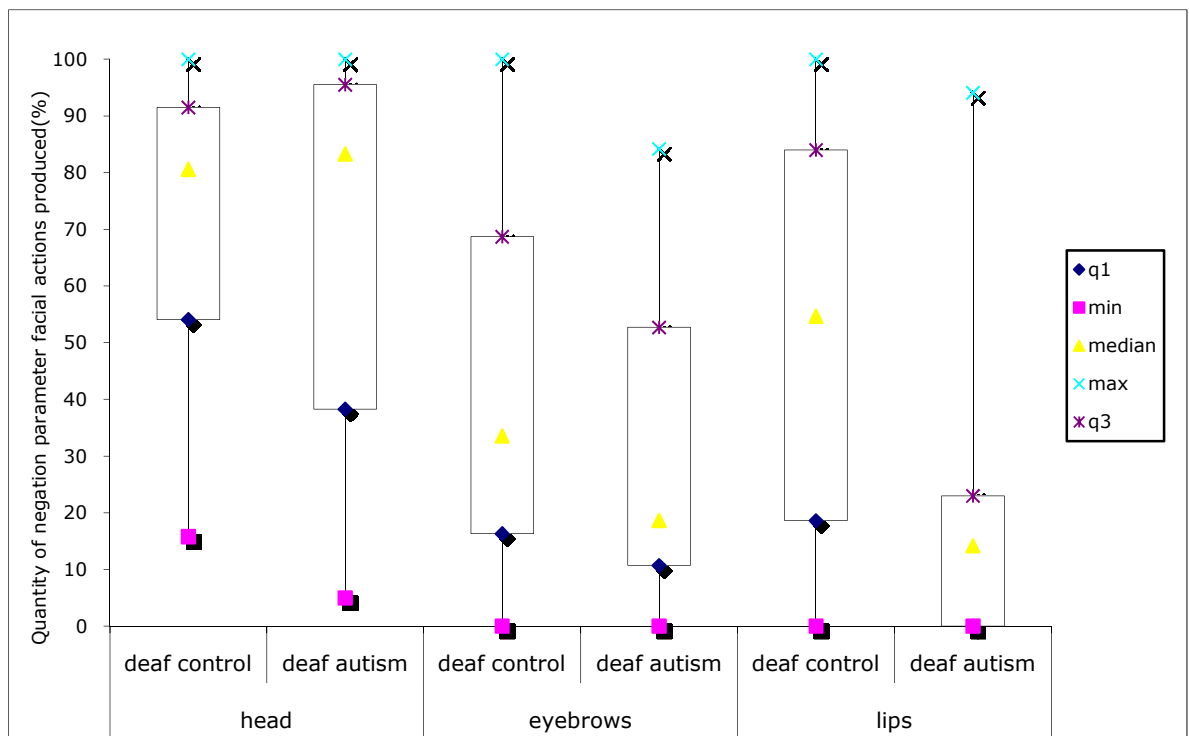


Figure 7:24: Box plot showing the production of negation facial actions using specific parameters in both groups

Figure 7:25: Deaf individual with ASD producing blank negation facial actions with manual sign NOTHING in the negation production test

Figure 7:26: Deaf control producing some similar negation facial actions on the negation production test

Figure 7:25 shows a deaf individual with ASD producing a negation sign, the manual sign ‘NOTHING’, the ELAN tiers demonstrate that no facial actions for negation are being produced, there is no head shake, eye brow furrow or mouthing, therefore the deaf individual with ASD has a total score of 0/3 for their production of negation. Despite this individual showing a lack of negation facial actions, the majority of deaf individuals with ASD were comparable to deaf controls. Figure 7:26 depicts a deaf control participant using a negative head shake and down turned mouth, however he omits the eyebrow furrow, therefore he receives a score of 2/3.

Discussion

Findings from the negation production test demonstrated that there were no significant differences between groups within this limited production paradigm. The deaf ASD group produced negation facial expressions of comparable quantity and quality to deaf controls. This follows expectations to some extent in terms of quantity. The current finding of no difference between the quality of negation facial expression targets is not consistent with findings from the previous chapters (5 and 6). The finding from the current experiment is comparable to those findings from experiments 5a and 5b suggesting that there are no differences between groups for comprehending and expressing negation facial expressions.

Groups differed in the extent that different types of facial actions were used during negation production. Both groups produced the head shake most often relative to eyebrow furrowing and downturned mouth. However a group difference emerged where the deaf ASD group was less likely to produce the facial target of downturned mouth during

negation productions compared to controls. The deaf ASD group may use their lips less in producing facial expressions of negation, because the mouth is less salient than head shake and eyebrow furrowing in negation facial expression. Or they may have a general disinclination to the mouth during signs. Alternatively the number of mouthings for negation production may have been reduced in the deaf ASD group due to more oral mouthings as a result of English influencing their BSL ability. The majority of deaf individuals with ASD either showed a complete absence of expression on mouth or they mouthed the English word 'nothing', suggesting that any of these explanations are valid. It would be interesting to conduct further detailed tests on the use of mouthing in deaf individuals with ASD to further explore these hypotheses. These findings of deficits with using the mouth are inconsistent with the literature as hearing individuals with ASD are hypothesised to be better at tasks involving use of the mouth compared to the eyes (Langdell 1978; Joseph & Tanaka, 2002; Klin et al., 2002).

The deaf ASD group may be unimpaired with producing negation relative to controls due to the presence of the head shake in negation, as it is not strictly a facial action. Additionally the head shake also has communicative origins (Argyle, 1988; Williams, 1997), which may make it easier for the ASD group to use. Each facial action was compared between groups for negation production and whilst both groups produced the head shake most often, the deaf ASD group did not differ on the use of the eyebrows in negation production as well as the head shake. If the head shake on its own had comparable scores for groups relative to eyebrows and the mouth than this would suggest that the head shake is indeed different to other facial actions. However the head shake and eyebrows both had similar productions between groups.

It could be argued that the methodology of this elicitation task is flawed in that it is not a communicative task per se, as participants are merely required to describe pictures. The paradigm may be overly simplistic and not as naturalistic as spontaneous conversations or narratives. Many of the signed elicitations that were produced by participants in the current task involved single negative signs, there were few negated clauses. Hendricks (2007) used an alternative methodology to elicit negation in Jordanian sign language. Participants were given questions that required a negative answer and were asked to tell short stories which featured negation. Therefore such approaches may be warranted in future studies, as this may reflect further group differences.

Overall Discussion

The findings presented in this chapter point to a number of conclusions regarding the comprehension and production of negation facial expressions in the deaf ASD group. No differences were found relative to the deaf control group in all three experiments. No support was found for the hypothesis that deaf individuals with ASD are impaired with using and comprehending facial expressions for negation.

These findings are not surprising given that several studies have indicated that negation may be an easier structure to learn relative to other linguistic structures. Boudreault and Mayberry (2006) found that negation sentences were the most accurately rated linguistic structures in the grammaticality judgment task for native and non-native signers of ASL. Morgan et al., (2007) in their study of Christopher (the hearing savant) demonstrated that his accuracy scores in the negation tests were not significantly different to a control group of hearing ASL learners.

In these three experiments, 8 trials involved an object being absent (e.g. APPLE NOTHING, DOG BONE NOTHING) and 13 trials involved an action being absent (e.g. THROW NOTHING, SLEEP NOTHING) it would be interesting to compare these different trial types in a further study using item analyses to see if deaf individuals with ASD have greater impairments producing and comprehending negation of actions, which are more person related than objects. A number of studies on hearing individuals with ASD have demonstrated that they perform better with objects than actions or person related stimuli (Hobson & Lee, 1989; Cattaneo et al., 2007; Wallace et al., 2008).

Alternatively both groups may have comparable performance because of the unique status of negation as a linguistic structure compared to other linguistic or affective expressions. Negation is linked to logic and contradiction, therefore it is important for individuals to learn about negation and use it in daily life, so that they can learn what is true and of developmental and cognitive importance “Negation plays a role in selecting logical systems for particular applications” (Gabbay & Wansing, 1999, p9).

The hypothesis of whether the deaf ASD group is impaired with the comprehension and production of facial expressions for other linguistic structures will be further tested in chapter 8 with the comprehension and production of questions in BSL.

Chapter 8: How do deaf individuals with ASD categorise and produce question facial expressions in BSL?

Introduction

Wh questions are named accordingly because they contain a manual question sign for which the equivalent English gloss begins with Wh (e.g. WHAT, WHY, WHERE). The manual sign is produced in conjunction with a facial marker (Sutton-Spence and Woll, 1999). Wh questions are expressed through furrowed brows, direct eye gaze and a backward head tilt (Pfau & Quer, 2004) (see Figure 8:1). Yes-no questions differ from Wh questions, as they require an answer with a yes or no response and they are not accompanied by manual question signs in BSL. For yes-no questions the NMMs consist of: raised eyebrows, widened eyes, a tilted head and the shoulders leaning forward (Pfau & Quer 2004; De Vos et al., 2009) (see Figure 8:2). The facial actions listed above are all important in question production, if only one or two of these actions, as opposed to all three were produced, this would not be a well formed question and would look odd. During both of these question types the facial markers typically accompany the entire clause.



Figure 8:1: Example of manual question sign WHAT and facial NMMs for Wh question



Figure 8:2: Example of facial NMM for yes-no question

Sutton-Spence and Woll (1999, p68) proposed that Wh questions can be distinguished from other sentences (in both spoken and signed languages) in three ways: 1) they contain a word or a sign that signals a question (e.g. WHAT, WHO, WHERE etc), 2) they have an intonation pattern or facial expression specific to questions and 3) they have a particular word or sign order. For example in spoken languages the Wh question word usually occurs at the beginning (left) of a sentence (e.g. what is your name?), however in BSL, the Wh manual question sign often appears at the end of the sentence (NAME YOU WHAT?), or in some instances the question sign can occur at both the beginning and end of a sentence (e.g. WHERE BOOK WHERE?) (Sutton Spence & Woll, 1999). This Wh sign copy is also seen in other sign languages (Zeshan, 2004).

Acquisition of questions in sign language

There is little research on the use of questions in sign languages, most studies focus on deaf children and their mothers. Reilly and McIntire (1991) documented the acquisition of manual question signs and facial expressions between the ages of 1:0-3:0 years old in deaf children. At 2:6 years they omit question NMMs and only produce manual question signs.

Deaf children do not produce Wh question NMMs with the manual sign again until they are almost 4 years old. These findings are supported by Anderson and Reilly (1997) who demonstrated a similar pattern of acquisition of negation manual and NMMs. Mayberry and Squires (2006) in their review of acquisition of NMMs in sign language state that deaf children master the production of NMMs over question signs at the age of 6:0 years (1 year later than negation). Similarly Lillo Martin (2000) demonstrated that questions are in fact acquired later than other non-manual structures. She conducted a longitudinal study of the spontaneous production of Wh questions in deaf children of deaf parents and found that they did not produce the correct NMMs for Wh questions until they were 6 years old. Bouldreaut and Mayberry (2006) stated that this delay in mastery of question NMMs occurs due to the difficulty in producing NMMs alongside manual signs and the varieties of word order that occur in Wh questions.

Yes-no questions are found to have a different acquisition pattern to Wh questions. Younger children do not omit the NMMs for yes-no questions. NMMs for yes-no questions typically first appear in the form of raised eyebrows over a single sign, at the age of 1:0-1:4 years old (Mayberry and Squires, 2006). Yes-no questions are not associated with specific manual signs, they are only marked by NMMs on the face and are usually spread throughout an entire clause unlike Wh questions (Emmorey, 2002).

Infants are not the only source of evidence on the acquisition and use of Wh questions in deaf children. Evidence also comes from mothers who sign to their infants. Reilly and Bellugi (1996) looked at Wh question production in videos of 15 deaf mothers signing with their deaf children (aged 0:9-2:8 years). Ten of these children and their mothers were studied cross-sectionally and a further five were followed longitudinally.

Findings demonstrated a clear pattern where most deaf mothers directed ungrammatical Wh questions (90%) to their deaf children (i.e. without the appropriate NMM) when their children were under 2 years old. However when deaf children were 2 and above, deaf mothers produced the appropriate NMM for Wh questions. This finding is supported by other research studies, which demonstrate that deaf children show an increase in syntactic development with a greater production of multi sign utterances after the age of 2 (Reilly & Bellugi, 1996). This finding appears to be unique to Wh questions, as deaf mothers still produce NMMs for yes-no questions. Three explanations have been given for this finding: 1) Deaf mothers use NMMs in Wh questions only after their children start producing them in their own sign output, as a scaffolding technique. Evidence in support of this explanation comes from Anderson and Reilly (2002) who demonstrated that deaf children first use Wh questions at approximately 18 months in the Communicative Developmental Inventory (CDI). 2) Deaf mothers may be simplifying the morphology of the Wh question sign by reducing the information to one channel and 3) Deaf mothers may withhold facial expressions for Wh questions because they create a potential conflict where similar facial regions are used in emotional expressions (e.g. surprise). Mothers may be favouring affect over grammar in their early use of questions with their children.

Comprehension of questions in sign language

There is only one known study to date looking at the comprehension of questions in sign language. Boudreault and Mayberry (2006) compared native, early and late deaf signing adults on their comprehension of Wh questions in a grammaticality judgment task. Half of the sentences had two manual question markers (WHY, WHO) alongside the obligatory NMMs for questions and the remaining half of the sentences consisted of the NMMs being

produced without the manual question sign. Both these sentence types were made ungrammatical by separating the Wh NMMs and the manual marker from the original clause. Findings demonstrated that accuracy was highest when the manual question marker was present, followed by NMM alone in the grammatical conditions and the two ungrammatical conditions (manual marker and NMM alone) which did not differ from each other. These findings demonstrate unsurprisingly that signers find it easier to comprehend questions when both manual and NMMs are present rather than NMMs alone, as the latter rely to a greater extent on face processing.

Question comprehension in ASD

A number of studies have compared the comprehension of different sentence types: questions, commands and statements in hearing individuals with ASD (Fosnot & Jun, 1999; Peppe et al., 2007; Chaida, 2008; Chevallier et al., 2009; Paul et al., 2009). Two studies demonstrate a deficit in children with ASD in comprehending questions. Fosnot and Jun (1999) compared children with ASD and children who stutter on their ability to read written sentences aloud. These sentences were either questions or statements (as demonstrated by a question mark). The children with ASD had impaired comprehension and production of the sentences. They failed to produce question intonation and all their utterances sounded like statements. Peppe et al., (2007) compared high functioning children with ASD with matched controls on an assessment (profiling elements of prosodic systems-children PEPS-C, Wells & Peppe, 2003; Wells et al., 2004), which charted ability to distinguish between spoken questions and commands. Children with ASD showed substantial deficits relative to controls with poor ability to differentiate questions using intonation alone. In light of these intonational deficits that appear to account for difficulties in comprehending questions in

hearing individuals with ASD, it would be expected that deaf individuals with ASD may show the same difficulties when comprehending both facial NMMs for questions and intonational cues. However results from the previous chapter demonstrate that the comprehension of negation requires both understanding of facial NMMs and intonation and the deaf ASD group were unimpaired with comprehending negation.

It is important to note that other studies failed to identify impairments in individuals with ASD in distinguishing between sentence types (Chevallier et al., 2009; Paul et al., 2009). Differences in methodology may have accounted for the lack of impairment in the ASD group in these studies.

In light of these findings, it will be interesting to explore how deaf individuals with ASD fare on a task that measures comprehension of questions and commands. To date there are no research studies that compare the comprehension of questions and commands in sign language.

Experiment 6a: Question categorisation test

Hypothesis

In light of evidence that hearing individuals with ASD show impairments with distinguishing between questions and other statements (Fosnot & Jun, 1999, Peppe et al., 2007) it is expected that

- 1) *The deaf ASD group will show impairments categorising NMMs for yes-no questions and commands. Because these devices are distinguished only by facial action.*
- 2) *Both groups will categorise the Wh questions (hands+face) with most accuracy relative to the yes-no questions and commands (face alone).*

3) *There will be no difference between groups for Wh questions.*

Methodology

Participants

Deaf ASD group (n=13) and deaf controls (n=12) were tested (see chapter 2 for group matching characteristics).

Materials

De Renzi and Vignolo's (1962) token test was adapted for the current experiment. This measure was used by Hickok et al., (1995) to assess comprehension of commands in a deaf signer with left hemisphere damage (LHD). Different wooden coloured shapes were arranged into various lay-outs. Suitable yes-no questions and commands were then devised regarding the lay-out of the shapes (e.g. *is the circle on the square? Put the circle on the square*). The sentences were created so that each yes-no question and command was identical, differing only in the NMM that was produced during sign production (e.g. CIRCLE ON SQUARE). Figure 8:3 demonstrates an example yes-no question and Figure 8:4 an example Wh question. Wh questions differed from yes-no questions, as they could be comprehended from both manual signs and NMMs (hands+face) (e.g. BLUE HOW MANY? ORANGE SQUARE WHICH NEXT?). The inclusion of Wh questions served as a control measure to ensure task comprehension and meta linguistic ability were not causing errors rather than difficulties with the comprehension of NMMs. Figure 8:5 demonstrates a command, featuring furrowed eyebrows, widened eyes and a head nod. Commands can differ from questions from their NMMs alone. There has been little research on commands in sign language, they are usually produced with stress (e.g. the sign

is made faster and sharper) and the signer maintains direct eye gaze with the attendee (Baker Shenk & Cokely, 1981; Valli & Lucas, 2000).



Figure 8:3: Example of yes-no question SQUARE CIRCLE NEXT?



Figure 8:4: Example of Wh question manual sign RED TRIANGLE WHERE?



Figure 8:5: Example of command PUT CIRCLE ON

A deaf native signer was filmed producing the stimuli at DCAL. The signer was first shown pictures of all the shape lay-outs and then she was given an English gloss of the sentences and instructed to produce each of the sentences as Wh questions, yes-no questions and

commands. The sentences were carefully observed by the experimenter during filming so that exactly the same manual sign strings were used for the yes-no questions and commands with the only difference between sentences being NMMs. Other sentences were comprehended through the use of NMM and manual markers (e.g. Wh questions, see Appendix 6 for list of questions and commands). These sentences were then edited and exported as QuickTime movie clips, each video-clip lasted approximately 4 seconds. The video-clips were renamed as a number so there were no labels revealing whether the clip was a question or a command. The task was then piloted on two deaf adult native signers in order to ensure ease in distinguishing between questions and commands, both signers had 90-100% accuracy. Ambiguous items were deleted, so only the clearest video-clips were used in the experiment. Fifty video-clips were used in the experiment (commands $n=17$, yes-no questions $n=19$ and Wh questions $n=14$). The order of the clips was counterbalanced, so half of the participants watched the clips in one particular order A and the other half watched them in order B, in both versions participants never saw more than two of the same sentence type in a row.

Procedure

Participants were first presented with two response cards labelled 'ask' and 'tell'. These had pictorial symbols to aid understanding (on the 'ask' card a question mark had been drawn beneath the written word and on the 'tell' card an index finger was drawn depicting the BSL sign TELL). The experimenter explained using BSL the difference between both a yes-no question or Wh question ('ask') and a command ('tell'). Participants were given examples of both sentence types by the experimenter (e.g. WINDOW CLOSE, HOMEWORK), as a yes-no question and as a command. Participants were told that they

would be shown several short video-clips of a woman signing about some coloured shapes (they did not see the shapes). They were asked to decide whether the woman was asking a question or telling them to do something at the end of each video-clip. Participants were presented with video-clips on a laptop computer, they could either respond by pointing to the ‘ask’ or ‘tell’ response cards, or they could sign their response as ask/question or tell. They were shown the clips one by one and the experimenter coded their response.

Results

The number of correct responses that participants made for each sentence type was calculated in Excel.

A non-parametric Wilcoxon paired test was calculated for each group. No difference was found within each group for yes-no questions and Wh questions (ASD: $Z=-1.7$, $p>.05$, control: $Z=-1.5$, $p>.05$), for yes-no questions and commands (ASD: $Z=-.089$, $p>.05$, control: $Z=-.86$, $p>.05$) and Wh questions and commands (ASD: $Z=-1.84$, $p>.05$, control: $Z=-.87$, $p>.05$).

Between groups analyses per condition using Mann Whitney tests demonstrated no significant differences for Wh questions ($U=-.311$, $p>.05$), yes-no questions ($U=-.277$, $P>.05$) and commands ($U=-.989$, $p>.05$).

Figure 8:6 shows a non-significant trend where Wh questions had the highest accuracy scores (Median: ASD: 85.7%, control: 85.6%), followed by commands (ASD: 76%, control: 82.3%) and yes-no questions (ASD: 68.4%, control: 65.7%) for both participant groups.

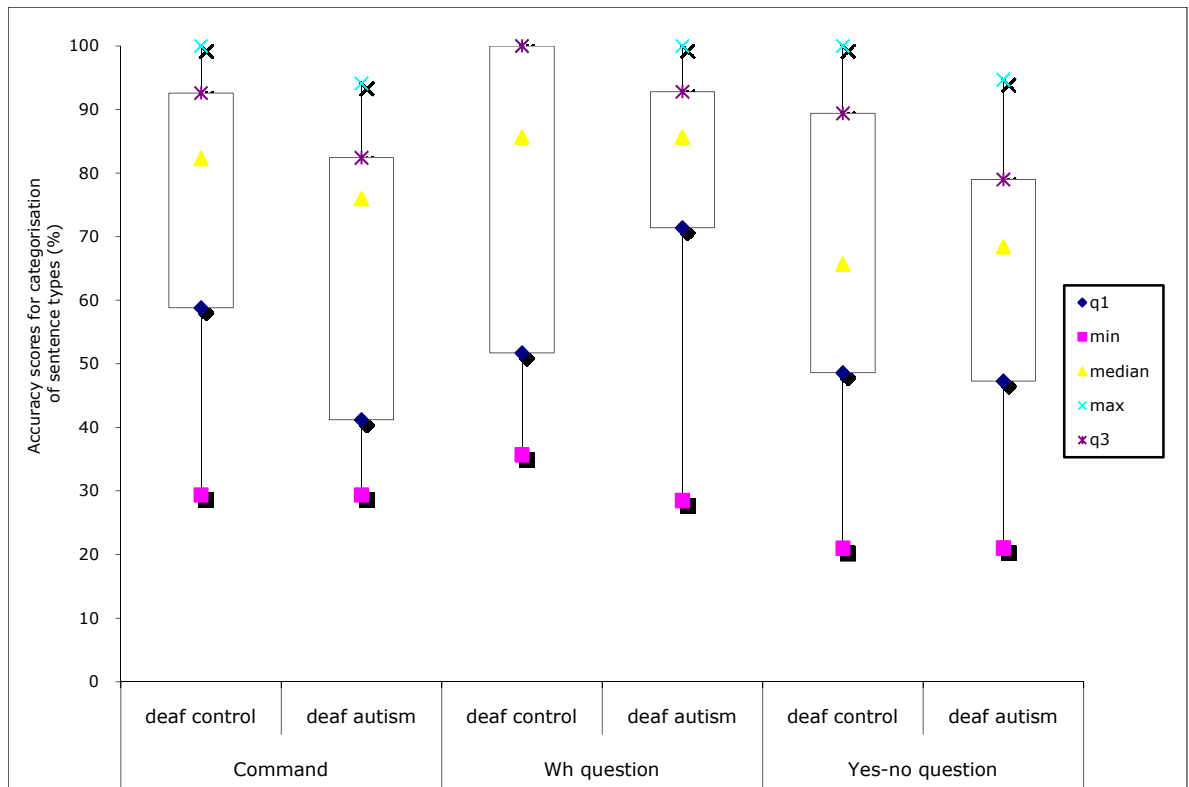


Figure 8:6: Box plot indicating correct recognition for questions and commands

Discussion

Results show no significant differences between the deaf ASD and control groups on their ability to comprehend questions and commands even when the question is purely distinguished by facial action. Taken in the context of previous findings of both impaired question recognition and recognition of facial expressions in hearing individuals with ASD- these results are surprising. This finding does not support hypothesis 1, which stated that the deaf ASD group would have impaired comprehension for yes-no questions and commands (which are distinguished by NMMs) relative to Wh questions (which are manually marked). Participants in both groups did not show significantly higher scores for Wh questions compared to commands and yes-no questions, therefore hypothesis 2 (which

stated that both groups would categorise Wh questions with most accuracy relative to yes-no questions and commands) was not supported. There was a non-significant trend where both groups had higher scores for Wh questions followed by commands and yes-no questions, suggesting the combination of hands+face led to somewhat easier comprehension of question type than face alone. There was no difference between groups for Wh questions so hypothesis 3 (which stated that there would be no difference between groups for Wh question comprehension) was supported. This finding that deaf people with ASD are not selectively impaired on BSL structures that are disambiguated by the face is extended here to question morphology, along with negation described in experiments 5a and 5b.

The median scores demonstrate that both groups understood the task equally with similar scores for each sentence type. However it is possible that some participants did not understand the task instructions as this is a hard task requiring metalinguistic skills. The accuracy scores are from 60-75% which is well above that expected by chance alone suggesting that this is not the case. It would be interesting to replicate the experiment with a measure of reaction time, as this may reveal subtle effects of difficulty with the different sentence types between groups.

One critique of this methodology was the slightly different number of items in each condition (Wh questions, yes-no questions and commands) this occurred after some ambiguous items were removed, ideally there should have been equal numbers in each group.

Chevallier et al., (2009) tested children with ASD and controls on their ability to distinguish questions from declaratives. A slightly different methodology was used where

participants listened to sentences and were asked to decide whether the speaker sounded sure or unsure or what he said. There were no differences between groups on either condition in accuracy or reaction time. The results from Chevallier's study suggest that children with ASD are able to detect questions, when the instructions make fewer demands on meta linguistic skills (such as knowledge about what a 'question' is). Chevallier et al., (2009) criticized methodologies where participants are asked to distinguish between someone asking or telling in English. They stated that asking can be synonymous with telling, as both acts involve giving new information to a listener. Alternatively children may perceive the question as being told what to do, so they may confuse this with a command. Therefore the two choices of 'ask' and 'tell' could have been confusing to children in both groups.

Groups may have not differed because participants were not explicitly instructed to look at the face during the task. If they had been perhaps this would have amplified impaired performance in the ASD group. It is possible that both groups used other cues rather than just the face (e.g. speed of signing) to identify the sentence types where no manual cue was present.

One criticism of the task is that it may have been too abstract, asking participants about shapes and colours of objects which were not present. The rationale for using these sentences came from a concern that talking about other objects may be even more complex. The use of object stimuli in the sentences may have facilitated the deaf ASD group as evidence suggests that they are less impaired with objects rather than social or human stimuli (Hobson & Lee, 1989; Cattaneo et al., 2007; Wallace et al., 2008). Hearing children typically acquire colour terms between the ages of 2;0-6;0 years old (De Lima

Velloso et al., 2009, Shatz et al., 1996) shape terms at 3:0 years (Samuelson & Smith, 2000) and space and size concepts at 3:5 years (De Lima Velloso et al., 2009). Therefore these terms should have been well understood by participants. There is no known research to date that looks at acquisition of these concepts in deaf children. However the experimenter checked that all participants were familiar with shape and colour terms prior to the start of the experiment. Designing a task which is methodologically strong and effective at measuring question comprehension in BSL is a challenging feat. Therefore despite the limitations that were associated with the current task there is little alternative and this is one of the first tasks measuring question comprehension in BSL to date.

Anecdotally it was noted by the experimenter that when the participants in the deaf ASD group were given the three questions at the end of the BSL narrative skills test (see Chapter 5) they had difficulty recognizing that they were being asked a question, however when they had to determine whether a sentence was a question or a command in the current task they were unimpaired relative to controls. It is possible that this task did not have direct accountability to the deaf ASD group (e.g. the fact that they did not need to give an answer may have enhanced performance). More research needs to be done to rule out this explanation, one way of testing for this hypothesis would be to give the deaf ASD group a series of direct questions to answer amongst other language tasks (sentence repetition, story-telling) to see whether they can recognize that they are being asked questions in a different context.

As the comprehension of negation and question NMMs requires both intonational and facial comprehension abilities it would be of interest to tease out these two explanations further to see if deaf individuals with ASD have similarly preserved

intonational and face processing skills or whether both areas are differently affected according to different types of task.

Results demonstrate that both groups are able to distinguish between Wh and yes-no questions. These findings are not comparable with those studies that demonstrate impairments in question identification in hearing individuals with ASD (Fosnot & Jun, 1999, Peppe et al., 2007). Experiment 6b extends the investigation of question use in deaf individuals with ASD by looking at the production of yes-no question NMMs.

Experiment 6b: Question production test

Production of questions in ASD

Hearing children with ASD often have difficulty producing Wh questions when communicating with others (Hurtig et al., 1982; Tager Flusberg & Sullivan, 1994; Naigles et al., 2008; Goodwin et al., 2009). Goodwin et al., (2009) looked at Wh question production in young children with ASD compared to controls who were matched on vocabulary scores. Participants were observed six times at four monthly intervals whilst they were playing with their mothers. Mothers were asked to complete the MacArthur CDI (Fenson et al., 1993) after each visit. Results from both the play observations and the CDI demonstrated that the children with ASD produced fewer different Wh questions and had lower overall percentages of question production compared with controls.

Smith et al., (2010) studied a hearing autistic savant ‘Christopher’ who was taught sign language (see Chapters 1 and 7 for further details) and observed over five periods. They specifically looked at his question production, in terms of both his spontaneous use of question signs and his ability to produce questions in a repetition task. Christopher

produced some manual Wh question signs (e.g. WHAT, WHERE and WHEN) however he failed to produce the appropriate facial actions, he even failed to produce question NMMs during repetition of question sentences. Therefore his signing looked odd and idiosyncratic. Christopher had few incidences of Wh questions and even fewer still of yes-no questions. Christopher showed good understanding of questions in the classroom, but he didn't use facial action to signal questions in his own spontaneous production. These findings demonstrate that hearing individuals with ASD may have difficulty with question use in both spoken and signed languages. Nevertheless findings from this thesis thus far suggest that impairments sometimes seen in hearing individuals with ASD may not always be present in deaf individuals with ASD.

Production of questions in sign language

Researchers often have difficulty eliciting naturalistic facial action in question production in sign language. The documented few studies have used different methodologies and coding systems to elicit and describe NMMs in question production. Baker Shenk (1983) looked at production of questions and statements in naturalistic conversation by two deaf signers. Their productions were coded using the Facial Action Coding System (FACS), (Ekman & Friesen, 1978; Ekman et al., 2002). FACS enables human coders to manually code nearly any anatomically possible facial expression, by classing facial muscular movements into specific Action Units (AU). AU involve a contraction or relaxation of one or more muscle (for example AU 2 produces an arched shape of the eyebrows, AU 4 flattens the eyebrows) (De Vos et al., 2009). Baker Shenk found that specific facial actions typically associated with Wh and yes-no questions did not occur in 30% of questions produced during natural conversation. In another study of question production, McIntire

and Reilly (1988) asked adult hearing learners of ASL to imitate NMMs including questions. They found that some novice learners of ASL did not distinguish between facial actions for yes-no and Wh questions, rather they used the same facial array to mark all questions they produced. They often made mistakes with the scope of their NMMs in Wh questions (for example they produced more intense facial action coinciding with the manual sign (e.g. WHO) rather than the whole sentence) suggesting that they acquired the NMM as a complement to a manual sign rather than as a sentence marker. McIntire and Reilly stated that these errors occur due to the purely communicative roles of these facial expressions in spoken language, interfering with their *linguistic* roles in sign language.

Coerts (1992) used short stories and picture cards to elicit questions in two deaf signers. A total of 95 yes-no questions, 34 Wh questions and 64 topic sentences were produced. A simple coding system was used which described neutral or up and down descriptions for eyebrow movements (Edinburgh non-manual coding system; ENCS) (Colville et al., 1984). Facial actions were not always consistently produced according to their corresponding question type, for example 40% of yes-no questions were found to have lowered eyebrows and 18% Wh questions had neutral or raised eyebrows. These findings are consistent with Baker Shenk, suggesting that question facial expressions are variable and inconsistent in terms of the facial actions that are produced for each question type. Question facial expressions may be produced with greater heterogeneity due to the relationship between linguistic and affective facial expressions in sign language. These studies whilst informative are also dated. De Vos and colleagues (2009) conducted a more recent study investigating question production in Sign Language of the Netherlands (NGT). In most sign languages including NGT eyebrows have the same functions (furrowed for

Wh questions and raised for yes-no questions), however universally in emotional communication eyebrows have separate functions, they are raised for surprise and furrowed for anger. Therefore there may be a conflict between the function of the eyebrows in both emotional and linguistic communication. De Vos et al., (2009) proposed two different hypotheses to describe how linguistic and affective eyebrow functions co-occur. Firstly affect may hold precedence over linguistic functions of eyebrow movement, so that an angry yes-no question is signed with furrowed eyebrows instead of raised eyebrows, this is known as the *affect over grammar hypothesis*. The second hypothesis states that both linguistic and affective facial expressions will be produced either simultaneously or sequentially. This is referred to as the *phonetic sum hypothesis*. De Vos elicited sentences which required either only linguistic or affective uses of the eyebrows. Two deaf native signers were recruited for the study in addition to a native deaf model. Forty pre-recorded sentences were used for elicitation featuring: yes-no questions, Wh questions, topics and declarative sentences. The model signed sentences in a neutral manner. The two participants were asked to repeat the sentences with different emotional expressions (e.g. 'angry', 'surprised', 'neutral' and 'distressed'). After they saw the signed sentence a word came up on screen corresponding to the emotion that they had to repeat the sentence in (e.g. 'angry'). Eyebrow movements were coded using FACS for brow movement and intensity. De Vos et al., (2009) found that when the eyebrow movement was compatible across both affective sentence and question type (e.g. an angry Wh question was asked) for which both affective and question components require an eyebrow raise then the movement of the eyebrows was enhanced, where eyebrow movement was incompatible (e.g. an angry yes-no question), then eyebrow movements were blended (i.e. they both occurred simultaneously

or one eyebrow movement was presented sequentially before the other). This study demonstrated that linguistic expressions are influenced by affective facial actions but the reverse pattern does not occur. Furthermore affective expressions do not assume a position of total dominance but rather emotional and linguistic facial actions are blended lending support to the phonetic sum hypothesis. Eyebrow furrowing appeared to have a stronger effect than eyebrow raises, regardless of whether the sentence type was affective or linguistic.

Taken collectively the research findings summarised above suggest that facial actions for questions are flexible across question type and co-occurrence with emotional expression. With the exception of Baker-Shenk's study (1983) these studies all use non-naturalistic methods of measuring question facial action production (i.e. with imitation or picture elicitation). The current experimental task adopted a naturalistic elicitation method and it was structured to reduce the variability of question production previously assumed by dichotomous categorisations of Wh and yes-no questions. The deaf ASD and control groups participated in a popular children's game involving question and answer turn taking ("Guess Who") (MB games) in a structured format. This study is the first known to use Guess Who as a paradigm for eliciting question production and the first to compare deaf ASD and control groups on their question facial expression production.

Hypothesis

Findings from the literature on hearing individuals with ASD demonstrating impairments in question production (Hurtig et al., 1982; Tager Flusberg & Sullivan, 1994; Naigles et al., 2008; Goodwin et al., 2009, Smith et al., 2010) lend support to the hypothesis that *deaf individuals with ASD will show impairments in question production relative to controls.*

However in light of findings from previous chapters (with comparable comprehension and production of negation NMMs and comprehension of question NMMs in the deaf ASD group) an alternative hypothesis states that the *deaf ASD group will show no difference in quantity and quality of question facial actions produced relative to deaf controls.*

Methodology

Participants

See experiment 6a participants section.

Materials

“Guess Who” a commercially available children’s board game was used to investigate the production of yes-no questions in the deaf ASD and control groups. Guess Who is a two player game, each player (the experimenter and participant) was given a game board featuring a set of characters (see Figure 8:7). Both players’ game boards featured the same characters, but they were differently arranged and not visible to their opponent. Each player had to pick a card from a pile on the table featuring one of the characters and proceed to take turns in asking yes-no questions in order to guess the other player’s character using a process of elimination. Characters differed in terms of gender, facial hair, hair colour, eye colour, and whether or not they wore a hat, jewellery or glasses. Questions were asked on the basis of these characteristics (e.g. YOUR PERSON GLASSES? MAN BROWN HAIR HAVE?) Responses are used to rule out certain characters (by flipping them down so they were no longer facing upright on the game board). If players asked the right questions their last character standing would match their opponent’s card. The first player to correctly guess its identity wins that round.



Figure 8:7: Example of game board for Guess Who and example of one of the characters

Procedure

Participants familiarity with “Guess Who” was checked (the majority had played the before in school or during speech and language therapy sessions). Where they lacked familiarity, the experimenter clearly explained each step of the game. For example, if a participant answered a question about the gender of the character as being female, then the experimenter would explain that they should flip all male characters down so that only the female characters were left upright and so on for various questions in a process of elimination. Sessions were video recorded to capture production of yes-no questions and concurrent question NMMs. On average each participant played two or three games. The last game played was used in analysis to ensure task familiarity and relaxed production. Analysed clips lasted approximately 3 minutes.

Coding system

A coding system was developed based on the production of two deaf adult native signers (details as in Chapter 5) whilst playing the game with the experimenter. The video-clips for each participant were edited and analysed using ELAN. Figure 8:8 demonstrates an example of the ELAN coding system and corresponding tiers. Two facial actions

consistently emerged as being fundamental in each of the adult's question productions: 1) raised eyebrows and widened eyes (these were grouped together, as they are often seen in unison and due to the physical demands of the facial actions where you cannot widen your eyes without raising your eyebrows) and 2) a head tilt. They were then used to code the participants' question productions using a 2 point scoring scheme with one mark for each feature present. The total score for question production was scored from 0-2. A score of 2 usually consisted of raised eyebrows, widened eyes and a tilted head, a score of 1 had one of these facial action components and a score of 0 meant no question facial expressions had been produced. The quality of facial expressions was scored as 'identical', 'similar', 'miscellaneous' and 'blank' (as in previous Chapters). Once coding was done for each participant, annotation statistics were exported from ELAN into Excel and SPSS.

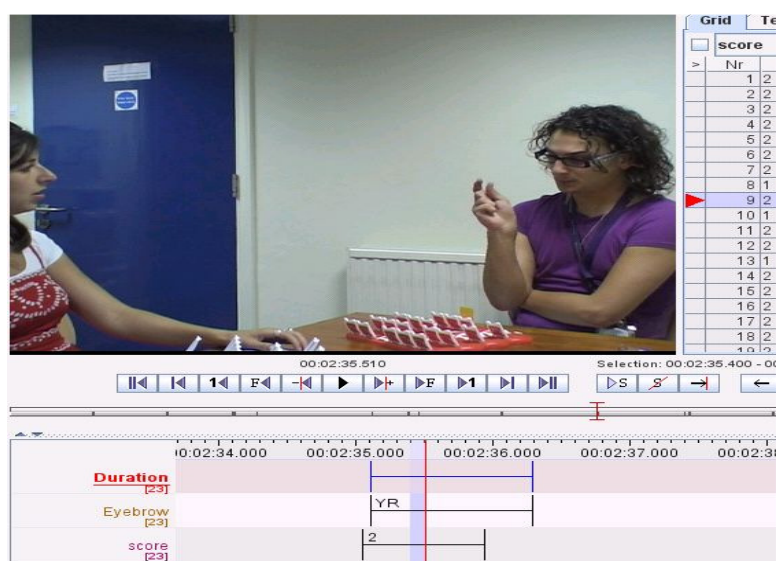


Figure 8:8: ELAN scoresheet showing a Deaf adult native signer producing a yes-no question in the “Guess Who” game

Results

The proportion of question facial actions (e.g. eyebrow raise, eye widen and head tilt) produced by each participant was calculated as a percentage of the maximum score for deaf adults. As a check of quantity, both groups were compared using a non-parametric Mann Whitney test on the number of questions that were asked during the game (both with and without facial actions). There were no differences between groups ($U(25) = -.027, p > .05$, Median: ASD: 12, control: 11.5). Then only the facially marked questions that were produced with correct facial actions were compared between groups, there was no significant difference between groups in quantity of facially marked questions between groups ($U(25) = -1.8, p > .05$) (although the numbers were approaching significance $p < .068$).

Figure 8:9 illustrates a slight trend between groups, where deaf controls produced more question facial actions during the game than the deaf ASD group, however this failed to reach significance (Median: ASD: 35%, control: 66.6%).

As in previous chapters, the videotapes of 5 participants were coded by the second rater (blind). The intraclass correlation between the raters for coding of quantity of question facial actions was .998.

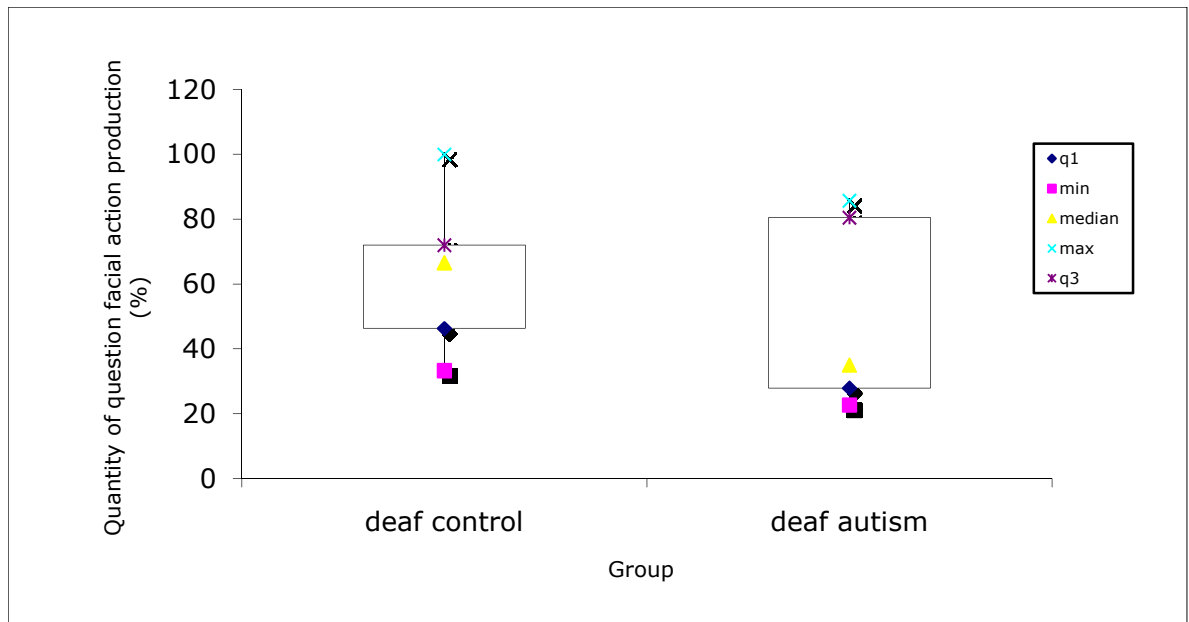


Figure 8:9: Box plot showing quantity of question facial actions produced by both groups during Guess Who

Groups were compared on the number of questions produced without facial action (i.e. had a score of 0), partial facial actions (a score of 1) and full question facial actions (a score of 2). No differences were found between groups across all categories (0: $U(25)=-1.2$, $p>.05$, 1: $U(25)=-.38$, $p>.05$ and 2: $U(25)=-1.7$, $p>.05$) (see Figure 8:10).

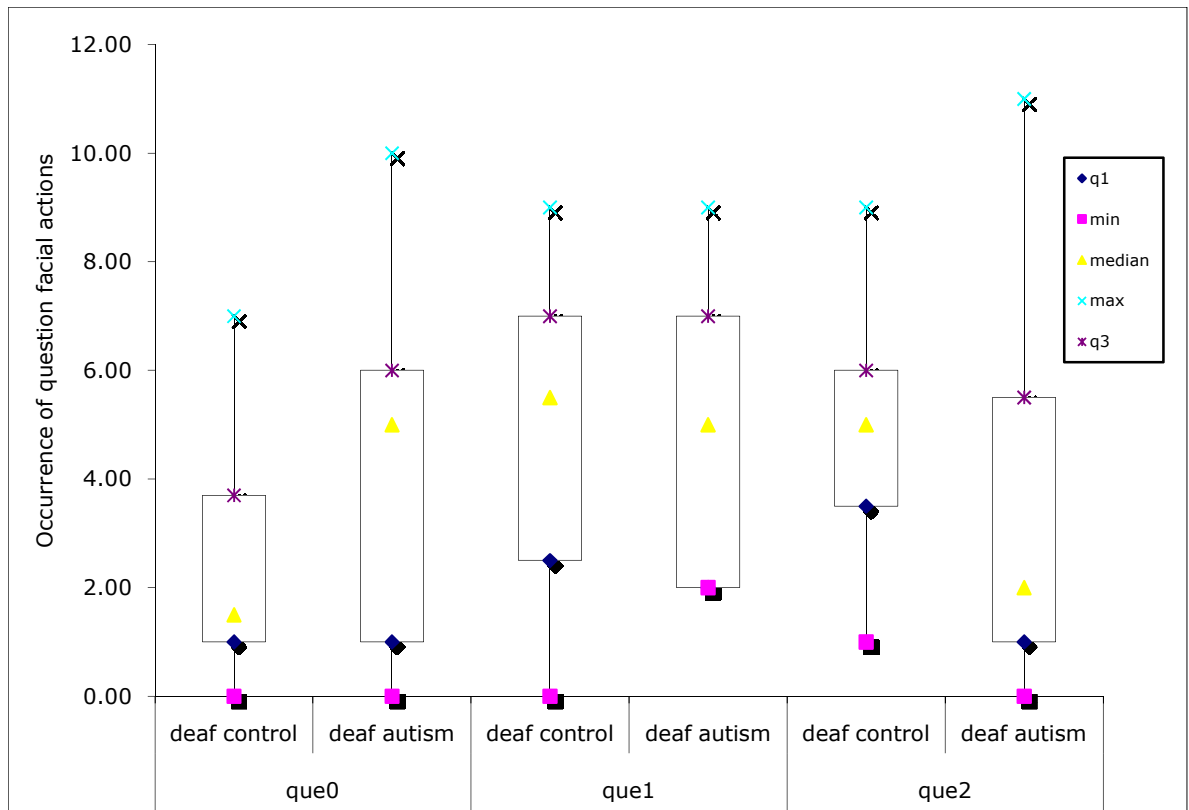


Figure 8:10: Box plots depicting occurrence of question facial action scores for both groups

The quality of question facial actions was compared between groups (identical, similar, miscellaneous and blank). There were no significant differences between groups for blank question facial actions. For the non-blank facial actions (identical, similar and miscellaneous) there were also no differences in quality between groups. Figure 8:11 reveals a trend in the data, where controls produced more question facial actions rated 'identical', however these findings are not statistically significant. The deaf ASD group did not produce any miscellaneous facial actions and deaf controls produced very few.

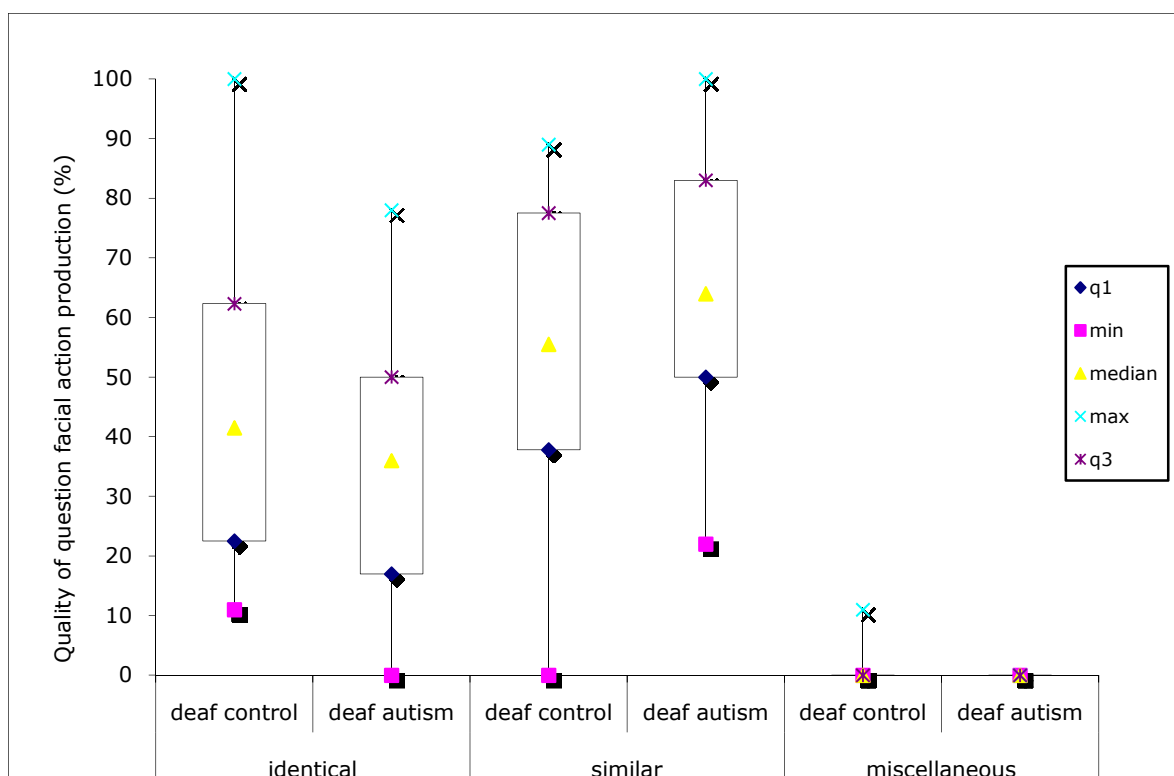


Figure 8:11: Box plot showing quality ratings of yes-no question facial actions during Guess Who

Figure 8:12: Example of a blank yes-no question “GLASSES?” produced by a deaf individual with ASD during Guess Who

Figure 8:13: Example of an identical yes-no question “MAN FAT WITH BEARD” by a control participant during Guess Who

Although, differences did not reach statistical significance, qualitative differences in question facial expression production emerged when looking in depth at the video data. In Figure 8:12 a deaf individual with ASD signs GLASSES? omitting all three facial actions. In addition to a lack of eyebrow raise, eye contact with the experimenter is avoided therefore making the question highly idiosyncratic. A robust feature of BSL questions is

that they are addressed to the respondent and directly intended. In this example there is a failure to mark the question and to monitor comprehension by the communicative partner, therefore in this example the participant scored 0. In contrast Figure 8:13 shows a deaf control participant signing MAN FAT WITH BEARD? She clearly addressed the respondent marked the question and monitored comprehension closely, her head is tilted back, eyebrows are raised and her eyes are widened, therefore she scored 2.

Discussion

The results indicate that the ASD group closely mirrors the controls in their ability to produce yes-no question facial actions. This supports the alternative hypothesis (that deaf individuals with ASD will show no difference in quantity and quality of question facial actions) as both groups produced yes-no question facial actions of comparable quantity and quality.

These findings are surprising in light of research studies demonstrating impairments in question production in hearing individuals with ASD. Hearing children with ASD were shown to produce a reduced quantity of Wh questions compared to matched controls (Goodwin et al., 2009). The fact that healthy deaf signers show inconsistencies in question NMMs and sometimes positions are used interchangeably connotating different question types (e.g. furrowed brows for yes-no questions, De Vos et al., 2009) may explain the current findings, as normal inconsistencies in usage may have obscured group differences.

A strength of the current study was the fact that a naturalistic question elicitation methodology was adopted. This ensured that all the questions produced were not reduced in facial expression as often is the case when signers are asked to produce sentences or repeat

sentences in an artificial context. Unfortunately it was not possible to elicit naturalistic Wh question production using the Guess Who format in the same way as these questions fall outside the scope of the game. The development of an alternative methodology to directly compare Wh and Yes-no questions represents a formidable challenge because it is difficult to elicit question production naturally, particularly as hearing individuals with ASD are often not motivated to ask questions, and characteristically show reduced turn taking ability and initiation of conversation (Loveland et al., 1988). Anecdotally during testing sessions deaf individuals with ASD rarely initiated conversation or asked questions despite experimenter attempts to engage them. It would have been of particular interest to collect data on the production of Wh questions in the deaf ASD group, as findings from research on hearing learners of sign language suggest that Wh question facial actions are harder to acquire and do not resemble cultural expressions produced by hearing English speakers when they ask questions in spoken language. The sentence repetition test (in chapter 6) did not feature questions in their linguistic sentences, it would be interesting to see how both groups would fare if they were asked to copy Wh questions (both with and without a manual marker) as repetition of questions would require both comprehension and appropriate production of the question NMMs.

The fact that affective facial expressions can override linguistic facial expressions during yes-no questions (De Vos et al., 2009) must be considered in interpretation. The game was quite challenging and participants had to think of questions to ask. This may have caused affective facial expressions such as puzzlement to be produced, which may disrupt question NMMs. Puzzlement is indicated by furrowed eyebrows, slightly squinted eyes and a downturned mouth and is similar in appearance to Wh questions (Corina et al.,

1999). This may have reduced the occurrence of yes-no question NMMs deflating scores for both groups. This assertion is supported by Campbell et al.,’s (1999) claim that eyebrow positioning can be driven by the attitude of the signer, so a puzzled person will produce a yes-no question with furrowed brows. However errors in this task were mainly an absence of question facial expression rather than a different facial action being produced (see Figure 8:12). It would be interesting to explore how both groups fare in a replication of De Vos et al., (2009) experiment. It is possible that the deaf ASD group may not show such an influence of affective facial expressions on linguistic structures (i.e. the phonetic sum hypothesis) in their question production, due to impairments with some affective facial expressions.

One limitation of the current study is the lack of measure for scope, it is possible that more subtle differences emerged between groups in the timing and co-ordination of their production of manual and non-manual questions. The current experiment is the first to attempt to look at question facial expressions in deaf people with ASD. Several experiments on question production have found variable findings (Baker Shenk 1983; Coerts, 1992). Perhaps more uniform measures of question facial expression coding need to be established, which involve developing coding systems prior to carrying out more research on atypical signers (e.g. deaf individuals with ASD).

Overall Discussion

The results from both experiments in this chapter suggest that the deaf ASD group show preserved question NMMs both in comprehension and production. This parallels the findings in previous chapters of spared negation NMMs.

It could be argued that ToM ability is involved in the use of question NMMs. Deaf signers need to be able to read the faces and intentions of their communicative partner in order to determine what type of question they are being asked (e.g. if a signer produced NAME? with Wh NMMs and an absence of the manual marker WHAT) individuals would need to recognise that this is a Wh question to respond accordingly, if DRINK? was produced they would need to recognise that this is a yes-no question. Subsequently signers need to learn how to produce their own appropriate question facial markers to convey to their communicative partner what type of question they are asking. Therefore question discrimination to some extent involves monitoring the intention of others. This ability to discriminate between these two sentence types appears to be unimpaired in the deaf ASD group relative to controls on the basis of comparable categorization of sentence types. Therefore it could be argued that ToM impairments that are associated with ASD do not impact on question use in deaf signers with ASD. Nevertheless the question types in the current experiment were about objects and facial features rather than emotions or mental states and it is possible that the deaf ASD group have difficulty with the latter rather than the former.

In the next chapter the use of adverbial NMMs will be explored in the deaf ASD group relative to controls. Adverbials arguably have a greater ToM component requiring the representation of the mental state of others, therefore it will be interesting to explore whether or not adverbial use is unimpaired in the same way.

Chapter 9: How do deaf individuals with ASD comprehend and produce adverbial facial expressions in BSL?

Introduction

Adverbials are facial signals which enrich the meaning of the manual signs with which they are paired. Adverbial facial actions express degree, manner, size, distance and affective information (Liddell, 1980; Bickford & Fraychineaud, 2008). They add substantial meaning “conveying much more information than would be expected given the translation of the individual signs in the sentence” (Liddell 1980, p42) and emphasis to signs (e.g. ‘VERY FAT’). Examples of adverbial facial actions include PUFF, where the cheeks are filled with air to signify something large (see Figure 9:1), MM, where the lips are protruded, this demonstrates that an action is being carried out with enjoyment (see Figure 9:2) and TH with protruded tongue, open lips and a relaxed jaw, where an action is carried out carelessly or with inattention. Other types of adverbials are PS, POW, PU, INT, CHA, STA and CS (see Table 9:1) (Bridges & Metzger, 1996; Tamar Jackson et al., 1997; Anderson & Reilly, 1998; Lewin & Schembri, 2009).

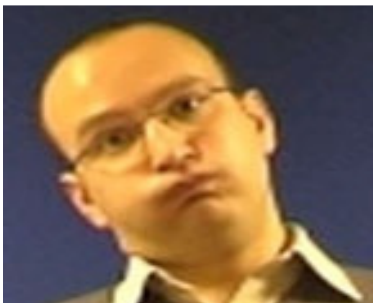


Figure 9:1: PUFF facial adverbial meaning LARGE or FAT



Figure 9:2: WALK with MM facial adverbial meaning with relaxation

ADVERBIAL NAME	Facial actions	Meaning	Example context
PUFF	Both cheeks filled with air	Large amount, too much	WOW LOOK MAN FAT
MM	Lips protruded	Relaxed, with enjoyment, discourse marker	ME DRIVE
INT 'ee'	Lips drawn back, teeth clenched together, eyes squinting	Great magnitude or effort	CONCERT C-O-N-C-E-R-T MANY PEOPLE
PS	Lips pressed together, drawn slightly back, mouth open in centre	Very thin, just missed	JET MISS TREE HIT
TH	Jaw relaxed, lips part, tongue protruding	careless, inattention	ME WORK CARELESSLY
STA	Teeth clenched, lips open slightly, jaw open and close	hard work, too much, intensity	LAST NIGHT ME AWAKE ALL NIGHT STUDY STUDY
CHA	Lips opened, teeth clenched, jaw drops open	relatively large	P-I-Z-Z-A ME LIKE
CS	Tight lips, drawn back on one side of face, teeth clenched	recently happened, close in space or time	RECENTLY ME FINISH TEST
PAH/PU	Tightly pressed lips open to form word PAH/PU	Finally	ME WAIT WAIT FINALLY BUS ARRIVE
IS	Lips spread, teeth visible, jaw open	Close, lucky, short	YOU LUCKY
POW	Tightly pressed lips open to form word POW	Become really angry	MOM POW

Table 9:1: Examples of different adverbial types (some ASL, some BSL definitions) with descriptions of facial actions and meanings

It is important to note that some adverbials described here have been given ASL glosses, this is largely because there is a greater prevalence of research into adverbials in ASL than in BSL. There is little research evidence stating that there are differences between ASL and BSL adverbials, with a brief description in Sutton Spence and Woll (1999). Some differences occur with how they are mouthed (e.g. the adverbial expression for the English word FINALLY is glossed in ASL as PAH and BSL as PU, Lewin & Schembri, in press). More comparative research between ASL and BSL adverbials needs to be done to rule out further similarities and differences. Largely research into adverbials in sign language is very sparse even within different sign languages.

Adverbials in sign languages are classed as mouth gestures; which “involve various configurations of the jaw, lips, cheek and tongue and imply some air movement or noises” (Fontana, 2008, p106). However adverbials differ from mouthings, as the latter are related to spoken language and involve articulating part or whole of the spoken word equivalent for a given sign (see Figure 9:3 for an example of a sign with an English mouthing DOG).



Figure 9:3 Example of English mouthing across the three photographs produced with the sign DOG

Adverbials are used to distinguish the meaning of otherwise identical manual signs, Figure 9:4 demonstrates that it is possible to distinguish between a description of a man driving (i.e. whether he is driving in a relaxed manner or carelessly) using identical manual signs MAN DRIVE but differing adverbials MM or TH.

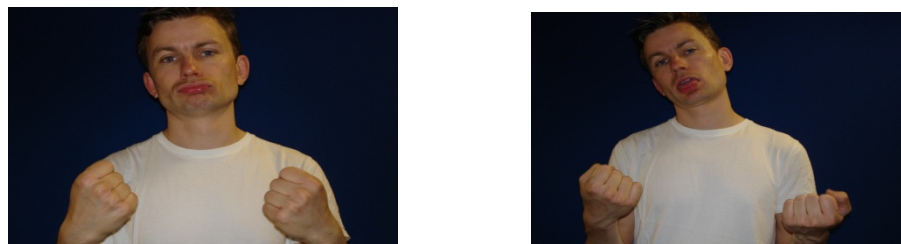


Figure 9:4: Adverbials MM (left) DRIVE IN A RELAXED WAY and TH (right) DRIVE CARELESSLY

Adverbials do not usually spread over manual signs other than those that they are associated with in a sentence (Neidle et al., 2000), for example MAN DRIVE would be produced with the adverbial MM or TH corresponding only with the manual sign DRIVE rather than for the full sentence. Anderson and Reilly (1998) described the features of adverbial non-manual markers (NMMs) in a mini review: they are limited to the lower face and always co-occur with a manually signed predicate (verb). For some adverbials a number of different predicates can be produced (e.g. MM and TH describe manner, they can occur with WALK, RUN, CLEAN etc), whereas others are quite specific (e.g. PUFF-LARGE, CS-THIN) (see Table 9:1 for further details).

Unique role of adverbials: adverbials and other NMMs

A number of researchers suggest a unique status of adverbials compared with other NMMs (Liddell, 1980; Sandler & Lillo-Martin, 2006; Neidle et al., 2000). Bickford and

Fraychineaud (2008) state that adverbials are different from other NMM structures in two ways: 1) adverbials are bound, they must co-occur with a manual sign and cannot be produced in isolation (unlike question and negation NMMs) and 2) they tend to occur in conjunction with single signs and they do not spread across phrases like other NMMs (e.g. head shake for negation).

Wilbur (1994) proposed that NMMs produced on the mouth and lower half of the face perform lexical or semantic functions. They provide adverbial and adjectival information that modifies the meaning of a noun or verb, whereas NMMs on the eyebrows and upper half of the face accompanied by head nods and body movement perform grammatical or prosodic functions. The localization of adverbials on the mouth contributes to the unique function of adverbials in a number of ways. Firstly any change associated with other facial features does not affect the adverbial meaning expressed by the mouth alone (Emmorey et al., 2008). Secondly adverbials are never produced with English mouthings, due to their own specific mouth configurations (Emmorey et al., 2008). For example, it is not possible to produce the BSL mouth pattern PU and FINALLY at the same time (see Figure 9:5 and Figure 9:6) or to produce a spoken English verb along with an adverbial (e.g. for DRIVE MM only MM is mouthed not DRIVE). If a signer mouths DRIVE then no adverbial is produced.



Figure 9:5: FINALLY manual sign with PU mouthing



Figure 9:6: FINALLY manual sign with corresponding English mouthing

In light of the observational research suggesting that adverbials differ in function from other NMMs (Liddell, 1980; Sandler & Lillo-Martin, 2006; Neidle et al., 2000), it would be interesting to make cross-group comparisons using the same methodology (i.e. adverbials and negation NMMs). Since the deaf ASD group were unimpaired with comprehension and production of facially expressed negation and questions, it would be logical to think that adverbials might also be preserved since they harness facial action to modify meaning in a similar manner. However differential impairment may emerge if adverbials are indeed functionally distinct from other NMM facial actions.

Adverbials and affective facial expressions

The argument that adverbials fundamentally differ from other non-manual linguistic structures (Liddell, 1980; Sandler & Lillo-Martin, 2006; Neidle et al., 2000) comes from the fact that they often conflate with affective facial expressions. For example adverbials may give information about the manner of an action and this is similar to emotional information (e.g. FOREST ME WALK THROUGH HAPPILY) (Sutton Spence & Woll, 1999). However McCullough and Emmorey (2005; 2009) argue that adverbials differ from emotional signs in a number of ways: 1) They can be used with a variety of predicates unlike emotional signs, which are usually bound to a specific lexical item (e.g. happy, sad); 2) Adverbials have a morphemic function unlike emotional signs; 3) A change in the strength or intensity of adverbial facial expressions does not convey any additional information, unlike changes in intensity to affective facial expressions. Such variation in the expression of facial adverbials is treated as phonetic variation that does not convey meaningful information; 4) Adverbial expressions cannot be easily named. There are no lexical signs (or words) that label these facial expressions unlike words for emotion. McCullough et al.,’s position is strengthened by an fMRI finding comparing deaf signers and hearing non-signers on their processing of adverbial and affective facial expressions. Adverbial facial expressions (e.g. MM, CS, TH, Intense, PUFF and PS) were signed with 10 different predicates (e.g. WRITE, DRIVE, READ, BICYCLE, SIGN, STUDY, RUN, CARRY, DISCUSS and OPEN). Affective facial expressions included happy, sad, anger, disgust, surprise and fear. Participants were asked to make same-different judgments for within-category pairs of static pictures depicting either adverbial or affective facial expressions. Lateralization was dissociated with left-lateralised adverbials for deaf signers

but not for hearing non-signers. Affective expressions were right lateralized for hearing non-signers and bilateral for deaf signers. These differences in localization for adverbials and affective facial expressions suggest that they are not similar in function.

Experimental studies of adverbials in sign language

There are relatively few studies looking at the use of adverbials in sign language (McIntire & Reilly, 1988; Anderson & Reilly, 1998; McCullough et al., 2005; Lewin & Schembri, 2009, in press; McCullough & Emmorey, 2009). Studies are mainly developmental and focus on acquisition, there are no known studies to date specifically looking at adverbial comprehension and production by deaf older children or adults.

Acquisition of adverbials in sign language

Anderson and Reilly (1998) investigated the acquisition of ASL adverbials using cross sectional naturalistic and elicited data on 52 deaf children who were aged between 1;0-4;11 years old. A longitudinal study was also carried out with a small subset of these individuals (ten children aged from 2;0-4;11 years old). Thirty seven children produced non-manual facial adverbials and 276 non-manual utterances were produced across all sessions. During the naturalistic observations children were found to initially produce manual predicates without facial adverbials. The first instance of a facial adverb being paired with a predicate was found at 1;11 years old, PUFF, MM and TH were the first adverbials used, they were mastered from 3;0-3;6 years. PAH, PS, POW and INT were acquired before the age of 4 years and CHA was acquired last at 4;8 years. Two adverbials, STA and CS were not produced by any of the children suggesting they may be acquired after the age of 5 years. Facial adverbials were only produced once children had acquired the sign that they referred

to. For example LARGE or FAT needed to be understood prior to the acquisition of the facial adverbial PUFF. The results from the longitudinal data followed a similar pattern strengthening the cross-sectional findings. The elicited adverbial productions were produced in a sentence repetition task, 15 children were asked to imitate 20 sentences featuring facial adverbials. Half of these sentences were grammatically correct and half were ungrammatical as they used incongruent non-manual adverbials (e.g. manual signs BOY FAT with facial adverbial PS meaning very thin). All of the children were able to reproduce the facial adverbials, 11/15 had 100% accuracy and 14/15 children had 80% accuracy. Results from the repetition task indicate that children are able to produce adverbials at a younger age than demonstrated by spontaneous production. Children were found to use INT, PS, and CHA at 2;8 years in the sentence repetition task, but 3;6 years in the naturalistic data. Forty one errors were found with the production of adverbials. Of those, 83% were timing errors, where the scope of the NMM did not correctly correspond to the manual predicate. Lexical category errors were the second most frequent type, with adverbials co-occurring with manual signs, for which facial adverbials are ungrammatical such as nouns (e.g. GRANDMOTHER- PUFF). For the incongruent sentences, some children informed the researcher that the sentence was incorrect and many children changed the anomalous adverbial to a possible adverbial (e.g. they produced BOY FAT with PUFF adverbial instead of the incorrect PS adverbial). These findings demonstrate that children are able to produce adverbials with correct timing and scope from an early age. Mayberry and Squires (2006) supported this early mastery of adverbials in deaf children, in their review they stated that deaf children master facial adverbials at the age of 5;0 years.

Adverbials may have a different pattern of acquisition, as they do not occur in the dominant spoken language culture or carry the same essential communicative function. This contrasts with negation and question NMMs which sometimes occur in the conversation of hearing people (e.g. Wh questions use an eyebrow furrow, which is also seen in affective facial expressions for puzzlement or surprise and the head shake in negation is also used communicatively in spoken languages. For adult hearing learners of BSL these cultural communicative behaviours may interfere with the learning of accurate NMMs in BSL). Another reason that they may be easier to learn is that they are always paired with specific predicates (e.g. PUFF-LARGE, MM-WALK/DRIVE or some form of action), unlike for example Wh question NMMs, which are less bound and occur with a number of different signs in a sentence (e.g. WHERE, WHO, WHY etc). Similarly the exact form of negation NMMs varies due to the optional status of the manual marker for negation (e.g. NO, NEVER, NOTHING etc).

McIntire and Reilly (1988) tested novice and advanced hearing learners of ASL on their ability to imitate NMMs in sign language, three adverbials were included in this task (TH, CS and MM) (see Table 9:1). The advanced hearing signers were able to imitate TH and CS, whereas the novice group could imitate TH but had difficulty with CS. Both groups were impaired with imitating MM. A common error associated with the adverbial MM involved replacing the adverbial with a smile suggesting that learners may be using semantics to influence facial actions. These findings demonstrated that learners of sign language appear to heavily rely on manual cues for the production of non- manual markers.

Adverbials in sign languages have no equivalent in spoken language, therefore it is impossible to make comparisons between hearing individuals with ASD (who speak

English) and deaf individuals with ASD. Although, there is no directly equivalent literature, a study that has broad parallels found a deficit in the imitation of action style among hearing individuals with ASD (Hobson & Hobson, 2008). They compared children with and without ASD on the ability to imitate an experimenter on goal directed actions and stylistic actions, where half of the actions were gentle and half were forceful. For example one half of participants (in both groups) had to do actions comprising forceful whisking and gently spinning ribbons etc. and the other half did the opposite (e.g. gentle whisking, forceful spinning of ribbons). Some of the styles adopted were incidental to the goal (e.g. whisking speed) and others were intrinsic (e.g. forceful ribbons to make figure of eight). Both groups performed similarly for goal directed imitation acts, however the children with ASD were significantly impaired at imitating stylistic actions. There was a significant group difference, where the majority of the children with ASD (13/16) did not imitate the experimenter's style when it was incidental to the goal compared to 2/16 in the control group. There were no significant group differences when the style was intrinsic to the goal, findings were mixed (10/16 in the ASD group and 4/16 in the control group did not imitate style at all, 2/16 in the ASD group and 8/16 in the control group did so half of the time, and 4 participants in both groups imitated style on every opportunity). The children in the ASD group showed uneven performance across the conditions by contrast the control group showed stable performance across all tasks. Hobson and Hobson (2008) hypothesized that copying goal-directed actions of another person does not require engagement with that person, however imitating style of the actions requires identification with the person in terms of the manner in which they executed an action. Hobson and colleagues (Hobson & Meyer 2005; Hobson & Hobson 2007) stated that social difficulties in ASD are caused by a

lesser propensity to identify with the psychological stance of others, which results in problems with sharing experiences and having empathy for others. Hobson differentiated this impairment from ToM stating that impairments in ASD originate from social and emotional problems which may then lead to impaired ToM. “Identification is a motivating...process that may have profound implications for children’s developing understanding of what it means to be a self and have person-anchored perspectives (i.e. theory of mind)” (Hobson & Hobson, 2008, p171). This identification with others based on the style of their actions has parallels with adverbial facial expressions as some adverbials provide information regarding the style in which a person has carried out an action (e.g. MAN CYCLE MM vs. MAN CYCLE INT indicates different ways in which a man is cycling, either with relaxation or effort). Therefore if hearing individuals with ASD are impaired in portraying this information regarding style of actions it is possible that deaf individuals with ASD will be differently impaired when comprehending and producing adverbial NMMs.

Research on adverbial facial expressions is sparse relative to other NMMs. This is the first known research study looking at the use of facial adverbials in deaf individuals with ASD. The two experiments in this chapter measure the comprehension and production of facial adverbials in deaf ASD and control groups.

Experiment 7a: Adverbial comprehension test

Hypothesis

It is expected that the deaf ASD group will show impairments relative to controls on the comprehension of adverbial facial expressions (expressed as reduced accuracy and

increased reaction time) and that impairments may exist where none were found for other NMMs (1).

In line with the findings from experiment 5a and 6a, both groups will be more accurate at comprehending adverbials in the hands and face condition than the face alone condition (2).

Methodology

Participants

Deaf ASD group (n=13) and deaf controls (n=12) were tested (see chapter 2 for group matching characteristics).

Materials

The facial adverbial comprehension task was created by selecting items which would elicit adverbial facial expressions either through specifying size (e.g. thin, fat, big, small) or manner (e.g. with effort, INT see Figure 9:7, or ease, MM). A range of images were taken from Clip-Art of items which varied in size (e.g. a big and a small dog, thin and thick pizza, see Figures 9:8 and 9:9) and of people performing actions in various ways (e.g. cleaning neutrally vs. vigorously cleaning). Each image was 400x400 pixels in size.



Figure 9:7: INT (effort) adverbial facial expression for manual sign PUSH

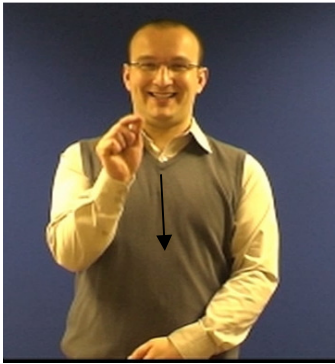


Figure 9:8: THIN manual sign and facial adverbial (PS)



Figure 9:9: THICK manual sign and facial adverbial (CHA)

Three of the predicates used in McCullough and Emmorey's (2005) study were used in the current study (RUN, CARRY, and BICYCLE). They were combined with the following adverbials: MM, INTENSE, PUFF, CHA and PS to form sentences which described the target pictures. All sentences were signed by a deaf native signer onto video (e.g. MAN CYCLE MM, DOG BIG PUFF etc). The signer used the target image to cue his descriptions. The signed representation closely matched the images. Participants watched each signed sentence and chose between two pictures (target and distractor) the signed sentence MAN CARRY BOX INT (see Figure 9:10) for example, with the facial adverbial for effort would be followed by two images; one of a man struggling to carry a box (target)

and another of a man carrying a box with ease (distractor) (see Figure 9:11). Similarly the signed sentence MAN CARRY BOX MM (see Figure 9:12) (with the facial adverbial for ease/relaxation) was also presented with the same response pair. Presentation was part-randomised with the rule that participants' did not see the same signed sentence with a different facial adverbial twice in a row (e.g. MAN CARRY BOX INT, MAN CARRY BOX MM).

Other examples include MOW LAWN INT (see Figure 9:13) and MOW LAWN MM (see Figure 9:14).

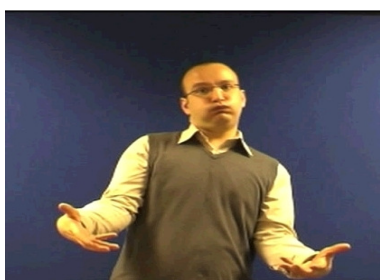


Figure 9:10: CARRY (with effort) (INT)



Figure 9:11: Example pictures from adverbial comprehension test for CARRY BOX INT (left) and CARRY BOX MM (right)

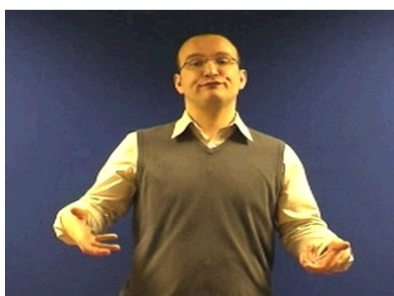


Figure 9:12: CARRY (with ease) (MM)



Figure 9:13: MOW LAWN (with effort) (INT)



Figure 9:14: MOW LAWN (with ease) (MM)

Altogether 39 signed sentences were used in this task, 28 of these used the same response pair (e.g. Figure 9:10 and Figure 9:12 with Figure 9:11) but target sentences had opposite

meaning. Fourteen signed sentences only used the response pair on one occasion (e.g. LAPTOP THIN) (see Appendix 7 for example stimuli used).

Sentences were grouped according to whether meaning could only be ascertained by attention to the face, or whether adverbial adjectivial information was also present on the hands, as a manual sign. Of these 39 trials, 16 were classified ‘face alone’ (where adverbial information was only on the face) for example for the signed sentence RUN manual signs would be identical for the target and distractor and only the facial adverbial differed (MM or INT) (see Figure 9:15 RUN TH). Twenty-three trials were labelled ‘hands+face’ and adverbial meaning could be distinguished using both manual signs and facial NMMs, for example LAPTOP THIN (see Figure 9:16) is composed of manually produced lexical signs LAPTOP and THIN combined with the facial adverbial PS which conveys size. The ‘hands and face’ adverbials cannot be produced solely on the face.

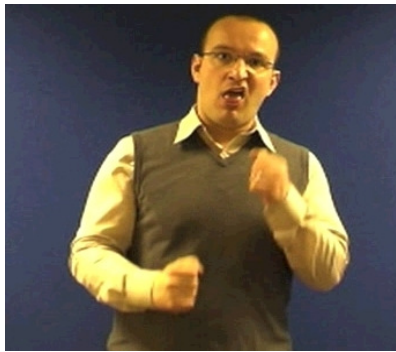


Figure 9:15: RUN (INT) (with effort) adverbial information on face alone



Figure 9:16: LAPTOP THIN (PS) adverbial information on hands+face

Procedure

Participants were instructed to watch video-clips of a signer producing different sentences and pick the corresponding image from two subsequently presented images. Participants responded by selecting keys on the keyboard depending on whether the image they had chosen appeared on the left (Z) or the right (M) of the screen. The target image appeared on the left and right side of the computer screen an equal number of times across the test. After each trial participants pressed space bar to start the next trial. This ensured that they did not miss any of the video-clips and that they could have a short rest after each trial. The images remained on the screen until participants had responded. There were two practice trials. Reaction time as well as accuracy was measured by keyboard press. If participants failed to respond within 6 seconds, the screen went blank and missed trials were repeated at the end of the task. This repetition of trials ensured participants did not miss trials due to distraction or momentary inattention to the task.

Results

A Kruskal Wallis non-parametric one way analysis of variance was calculated for 'hands+face' and 'face alone' adverbial conditions for both groups. There was a significant

difference between groups for hands+face ($H=5.2$, 1df, $p<.05$) and face alone ($H=5.9$, 1df, $p<.05$) with controls showing greater accuracy than the ASD group. Figure 9:17 shows that controls had significantly higher scores for the ‘hands+face’ condition (Median: ASD: 90.4%, control: 95.2%) and an even more marked difference on ‘face alone’ conditions (Median: ASD: 62.5%, control: 90.6%) compared to the deaf ASD group.

A wilcoxon signed ranks test was used to compare within group differences in accuracy score between the ‘hands+face’ and ‘face alone’ condition. The ASD group had significant differences between the two conditions ($Z=-2.5$, $p<.05$, Median: ‘hands+face’: 90.4%, ‘face alone’: 62.5%). The control group showed no significant difference ($Z=-1.3$, $p>.05$, Median: ‘hands+face’: 95.2%, ‘face alone’: 90.6%). The ASD group found the ‘face alone’ condition considerably harder relative to the ‘hands+face’ condition.

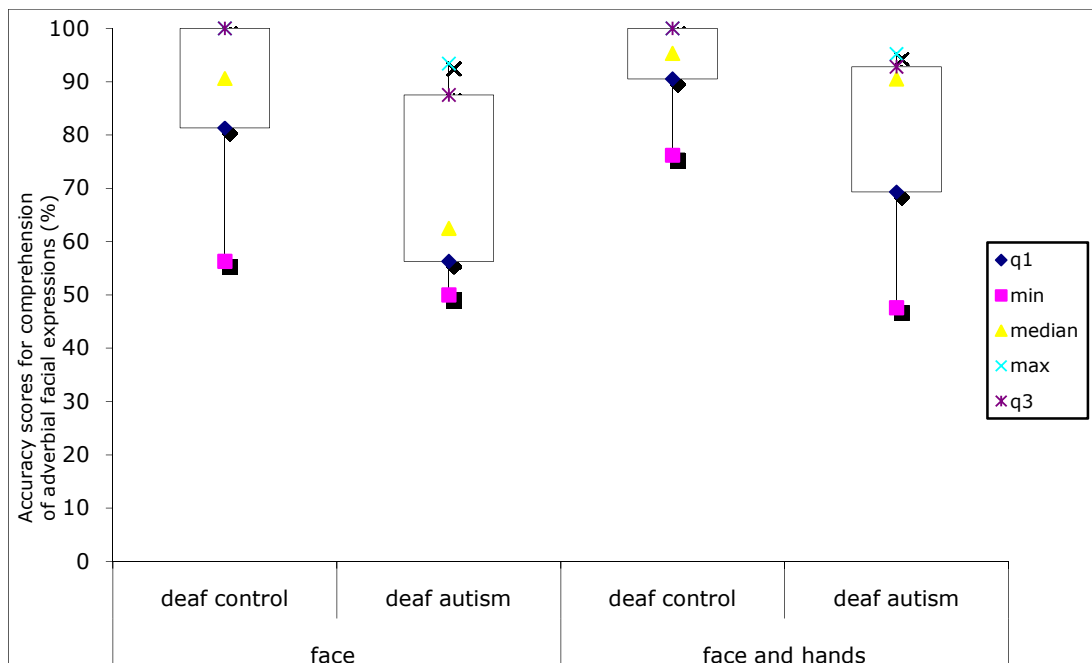


Figure 9:17: Box plots illustrating accuracy scores (%) of adverbials on the face alone and hands+face in both groups

For reaction time, the Kruskal Wallis tests demonstrated that there were no differences in speed between groups for ‘hands+face’ ($H=3.0$, 1df, $p=.08$) and ‘face alone’ ($H=.18$, 1df, $p=.66$). Both groups took longer to respond in the ‘face alone’ condition (Median: ASD: 2489.3 ms, control: 2562.1 ms) compared to the ‘hands+face’ condition (Median: ASD: 2645.3 ms, control: 2122.7 ms). Despite not reaching significance Figure 9:18 shows a trend where the ASD group took slightly longer to respond than the control group.

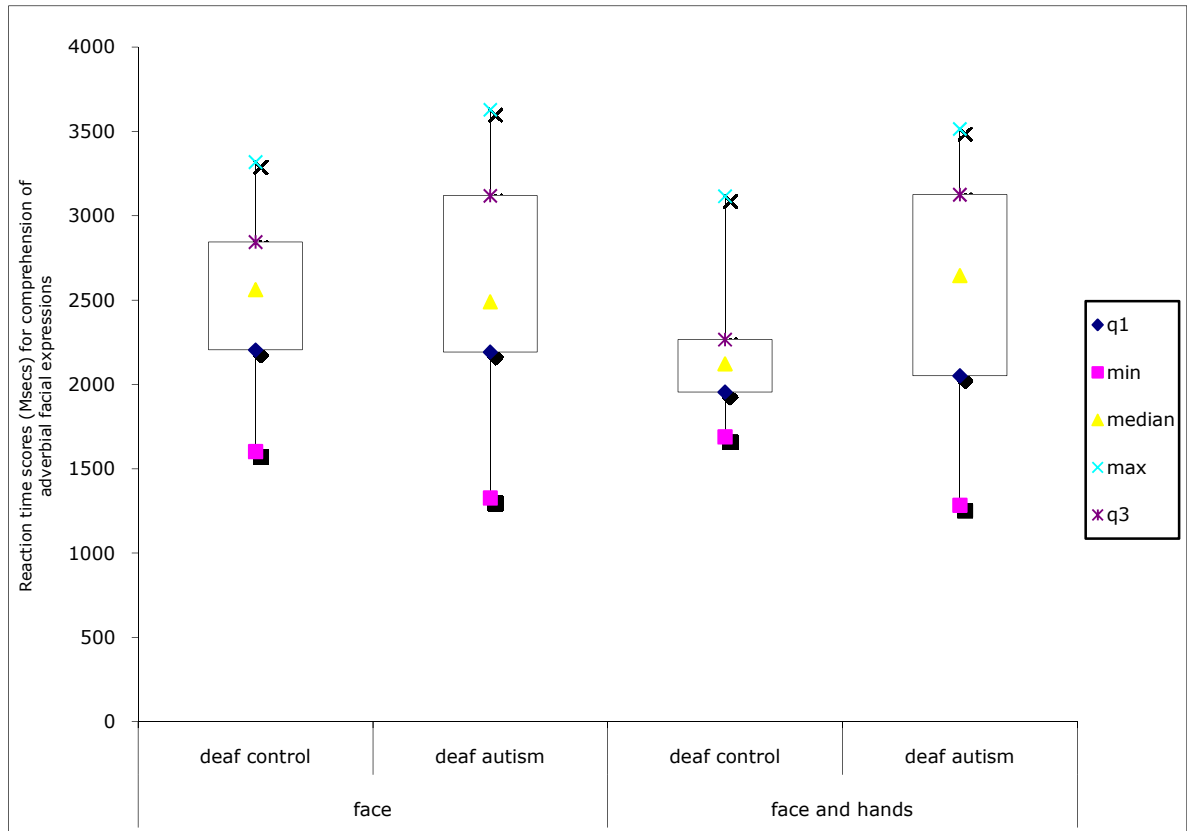


Figure 9:18: Box plots of reaction time scores for adverbial on ‘face alone’ and ‘hands+face’ conditions for both groups

Discussion

The deaf ASD group performed above chance and showed no significant difference in reaction time, indicating that the task was well understood, however their comprehension of purely facial adverbials was less accurate than controls. This also held true for sentences where adverbial information could be gleaned from the hands. This finding was consistent with the hypothesis that the deaf ASD group would comprehend fewer facial adverbials than controls. Thus the ASD group has a specific and significant impairment relating to adverbial comprehension, which was not seen on tests of negation and question comprehension. This finding strengthens the argument that adverbials have a unique function relative to other non-manual linguistic structures in BSL.

The deaf ASD group were less accurate than controls in the ‘face alone’ condition suggesting difficulty integrating facially expressed linguistic information. A significant impairment when adverbial information was available manually, although to a lesser degree, was also apparent. The fact that participants are not as might be expected, able to exploit manual cues to bring scores up to the normative levels of the control group suggests that impairment is not contingent only on face processing ability, but may be attributable to a more general deficit.

Findings from this experiment, 5a, 5b and 6a all show a similar pattern, where participants comprehend the ‘hands+face’ condition more accurately than the ‘face alone’ condition, this is consistent with the hypothesis. The comprehension task followed a similar format to experiment 5a for negation, therefore methodological explanations cannot account for the reduced performance of the deaf ASD group in the current experiment.

One methodological limitation with the current task is the fact that all the size related adverbials were in the ‘hands+face’ condition and all the manner related adverbials were in the ‘face alone’ condition. This is because size related adverbials are produced with compulsory manual signs accompanying them (e.g. LAPTOP THIN is signed with both laptop and thin as manual signs with a co-occurring facial adverbial produced with thin) and manner related adverbials are not (WALK MM involves the manual sign walk being produced with a co-occurring facial adverbial over the sign WALK). Therefore it could be argued that the deaf ASD group have a greater impairment with adverbials relating to manner than size. However it is important to note that the deaf ASD group had a deficit with the size related adverbials too. In order to further explore this impairment with facial adverbials in the deaf ASD group the production of the ‘face alone’ adverbials was compared with that of controls.

Experiment 7b: Adverbial production test

Hypothesis

It is expected that the deaf ASD group will produce fewer adverbial facial expressions and these will be of reduced quality compared to deaf controls.

Methodology

Participants

See experiment 7a participants section.

Materials

Photographs were taken of individuals undertaking different activities in 1) a neutral/relaxed condition and 2) a strenuous condition (e.g. a woman carrying a small suitcase vs. a woman straining carrying a heavy suitcase) (see Figure 9:19 below).



Figure 9:19: Images used for adverbial production test

Seven different models were used in the photographs (five men and two women of varying ages, six of whom were deaf). Two different photographs were taken for each action: 1) neutral/relaxed and 2) effortful (e.g. mowing a lawn, walking a dog or holding an umbrella etc). Of a total of 18 photographs, four corresponded to sentences that were used in the adverbial comprehension test (e.g. MAN CARRY WEIGHT, UMBRELLA HOLD, MAN DOG WALK and CARRY BAG), however different images were used and the testing was completed at least 2 weeks later to minimise interference.

Procedure

Participants were presented with photographs displayed on a laptop computer one at a time. They were asked to describe in BSL what was happening in the photographs. All photographs were shown in the same order with the neutral/relaxed action first followed by

the more strenuous action. Participants were filmed during the task to facilitate later analysis.

Coding system

The adverbial production task was given to two deaf adult models in order to develop a coding system (see chapter 5 for details). The video-clips for each participant were edited and analysed using ELAN. Each video-clip in ELAN was paired with a 3 tiered coding template. Each tier documented a parameter relevant to the signed production of the adverbials: 1) number of target items/facial actions that the two adult models produced for each item, 2) number of target items that each participant produced for the item and 3) extent to which NMM production matched the adult sign models (see Figure 9:20).

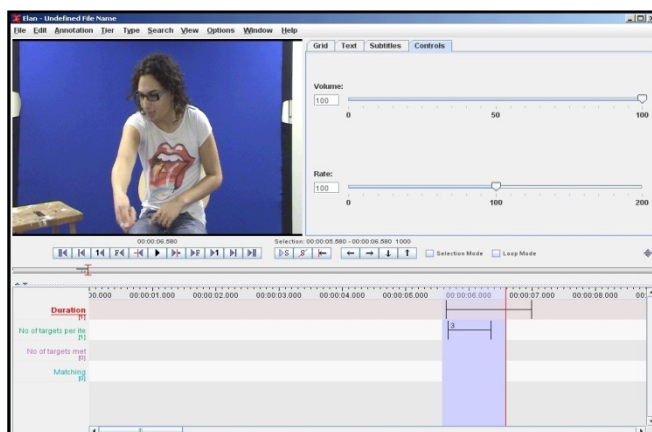


Figure 9:20: Example of ELAN score sheet of deaf adult signer producing an adverbial facial action (TH) in the adverbial production test for MAN DOG DRAG

Each item had a target number of facial actions based on the two adult native signers' productions. For example a photograph of a man walking his dog in a relaxed manner elicited MAN WALK DOG MM, with facial actions including raised eyebrows and lips

pursed forward. Therefore for this item there were two target facial actions against which participants' performance was measured. If the participant produced both of these facial actions they were given a score of 2, if they only produced one of the facial actions (i.e. they produced raised eyebrows but not the lip protrusion) they were given a score of 1 and if they failed to produce any facial expressions they were given a score of 0. The degree of similarity of participants' facial actions to those of the adult models (quality) was coded (identical, similar, miscellaneous and blank facial expressions, see chapter 5 for details of the coding system). Frequency of occurrence in each category was scored as a percentage of the total number of target facial actions. Once coding was done for each participant, annotation statistics were exported from ELAN into Excel.

Images used	Adverbial	Target facial actions	ELAN max coding
Man walking dog relax	MM	eyebrows raised, lips pursed forward	2
Man walking dog effort	TH	eyebrows raised, mouth downturned	2
Man mowing lawn relax	MM	lips forward, eyebrows raised	2
Man mowing lawn effort	INT	eyebrows raised then furrowed, lips pursed forward	2
Bag carry relax	MM	eyebrows raised, lips pursed forward	2
Bag carry heavy	INT	eyebrows raised then furrowed, lips pursed forward	2
Drive neutral	MM	eyebrows raised, lips downturned/pursed forward	2
Drive relax	MM	eyebrows raised, lips pursed, puff cheeks	3
Carry shopping bag relax	MM	eyebrows raised, lips forward	2
Carry shopping bag heavy	INT	eyebrows furrowed, lips forward/mouth open	2
Laptop work	INT	eyebrows raised, lips forward	2
Laptop relax	MM	eyebrows raised, tongue protruded, lips forward	3
Carry weights relaxed	MM	eyebrows raised or furrowed, lips forward	2
Carry weights heavy	INT	eyebrows raised or furrowed, tongue protruded, lip stretched, mouth open	3
Balloon blow up relax	MM	eyebrows raised or furrowed, puff cheeks	2
Balloon blow up effort	INT	eyebrows raised, puff cheeks, downturned mouth	3
Umbrella walk neutral;	MM	eyebrows raised	1
Umbrella walk effort hold	INT	eyebrows raised, pursed lips, stretched mouth	3

Table 9:2: Target facial actions for each picture

Results

The percentage of target adverbial facial actions was calculated by dividing the total score for adverbial facial actions produced for each participant with a total maximum possible score of 40 (e.g. if a participant produced 27 targets, this yielded a score of $27/40=67.5\%$).

Percentage scores were then compared between ASD and control groups using a non-parametric Mann Whitney test. A significant difference was found between groups

($U(25) = 35.5$, $p < .05$). Figure 9:21 shows that the deaf ASD group produced fewer adverbial facial actions than deaf controls (Median: ASD: 42.5%, control: 70%).

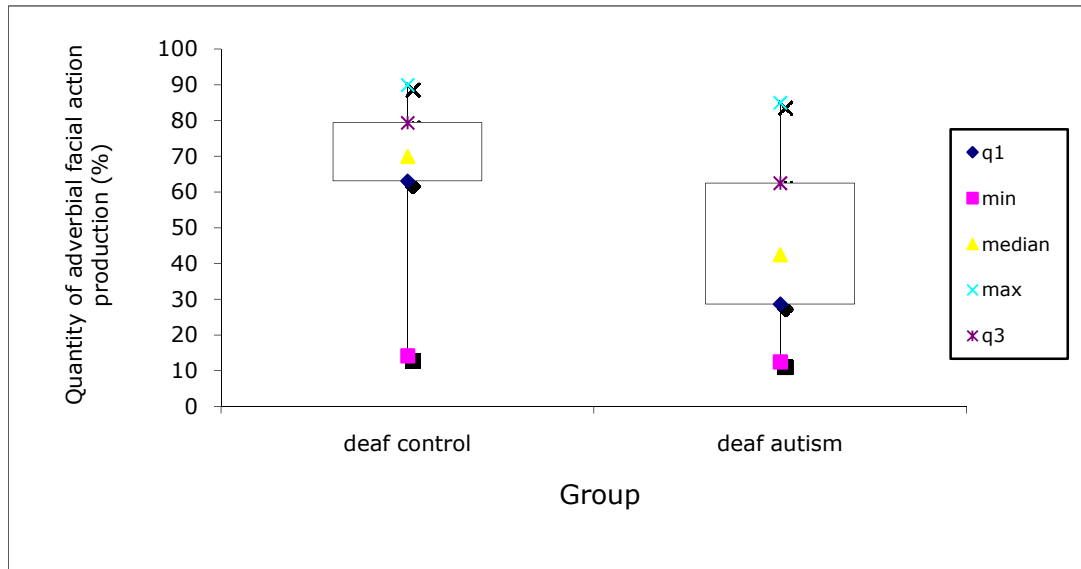


Figure 9:21: Box plot showing percentage (%) of adverbial facial targets produced

Twenty percent of participants were coded by a second rater using blind rating (the same five participants that were coded by the second rater in chapters 5-8). The intraclass correlation between the raters for quantity of adverbial facial actions produced was .968.

The duration of adverbials produced was also compared between groups (in terms of duration of the manually signed sentence which included facial action) and no significant difference was found ($U(25) = 51$, $p > .05$). This suggests that the ASD group were not using strategies such as lexicalisation where they used manual signs instead of producing adverbial facial actions (e.g. BAG HEAVY, which would have a longer duration than BAG INT).

Both groups were compared using a non-parametric Mann Whitney test for the number of facial actions that they produced (with a score of 0, 1, 2 or 3). These comparisons were made to further highlight how both groups differ in the production of adverbial facial expressions (i.e. does the ASD group produce some adverbial facial actions receiving scores of 1 and 2, or a lack of any facial actions with consistent scores of 0?). A significant difference was found between groups for the number of adverbial facial actions with a 0 score (e.g. manual signs that were produced with an omission of adverbial facial actions) ($U=37.5$, $p<.05$) (Median: ASD: 13, control: 12). These findings demonstrate that the ASD group produces expressions with no adverbial facial actions significantly more often than controls (see Figure 9:22). There was also a significant difference between groups for scores of 2 ($U=40.5$, $p<.05$) (Median: ASD: 6, control: 10.5). The deaf controls produced more adverbial facial actions with scores of 2 compared to the ASD group. No significant differences were found between groups for scores of 1 ($U=64.5$, $p>.05$) (Median: ASD: 5, control: 5) and scores of 3 ($U=66.5$, $p>.05$) (Median: ASD: 0, control: 0).

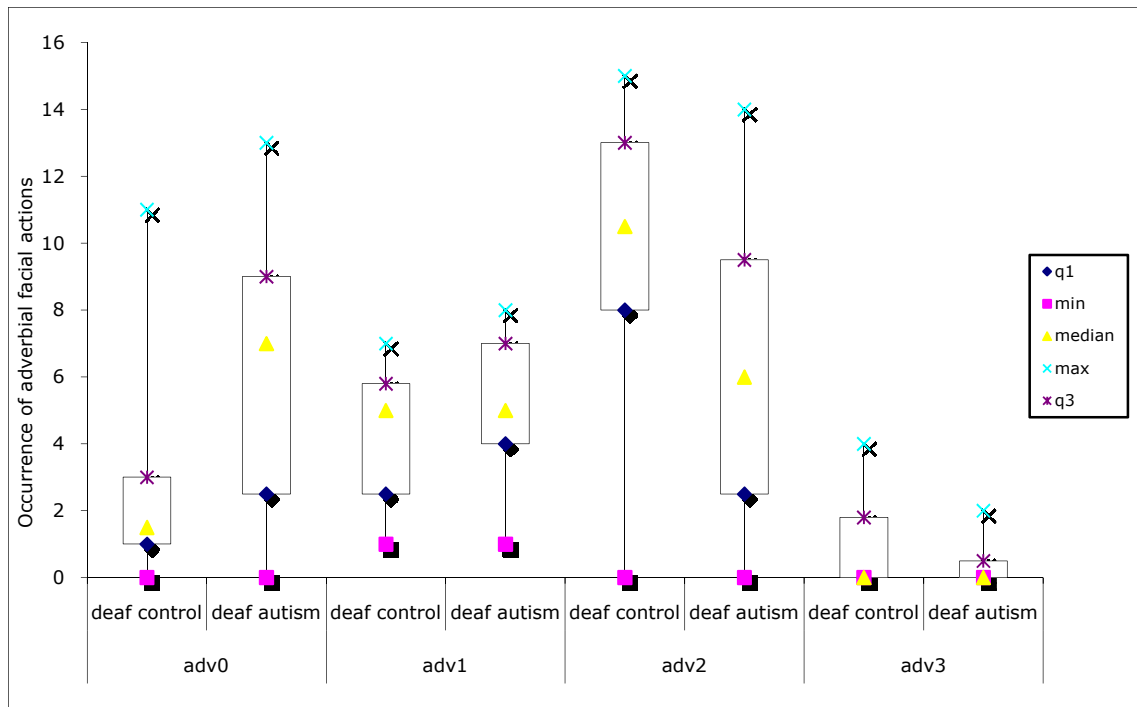


Figure 9:22: Box plot showing frequency of adverbial facial actions for both groups

Both groups were compared on the quality of ratings for adverbial facial actions, the coding criteria was: identical, similar, miscellaneous or blank (see Chapter 5 for further details). A non-parametric Mann Whitney test compared frequency of non-blank facial actions produced (identical, similar and miscellaneous). No significant group differences were found for each category. Figure 9:23 shows that the controls produce more adverbial facial actions rated identical than the ASD group who in turn produced more actions rated similar, however these differences did not reach significance.

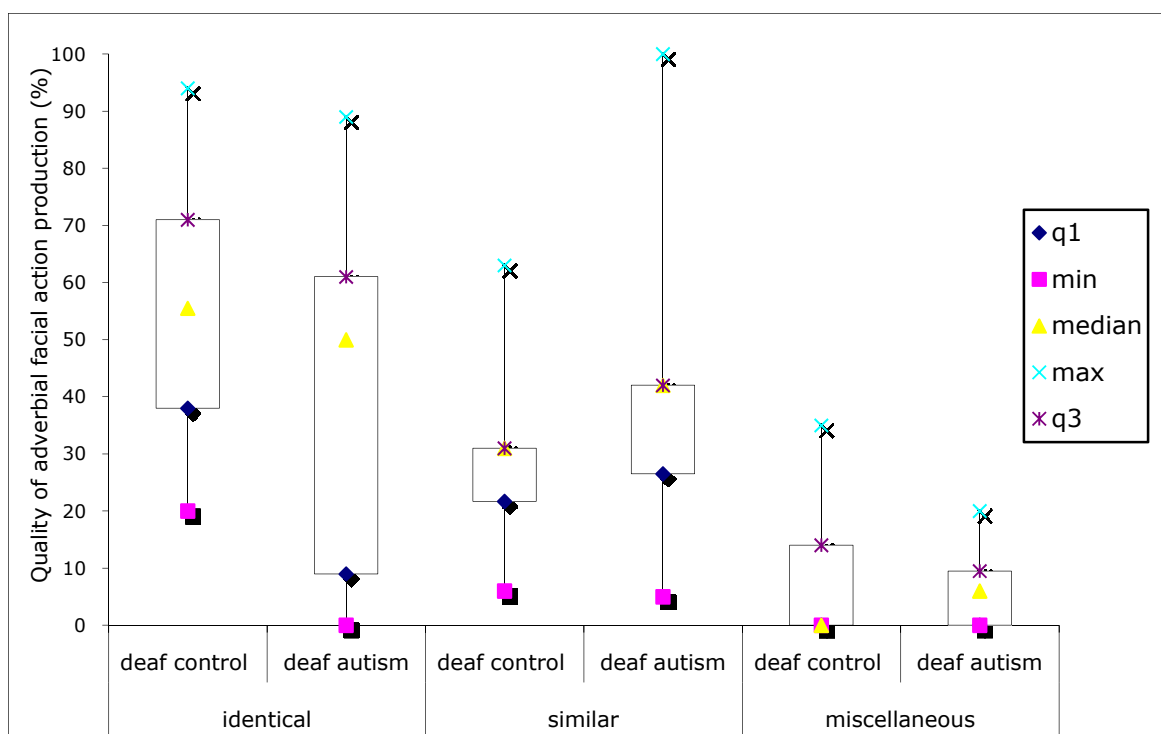


Figure 9:23: Box plot showing quality ratings of adverbial facial actions in the adverbial production test

Adverbial facial actions were further analysed with both groups compared on their production of 'neutral/relaxed' vs. 'effortful' adverbial facial expressions. A non-parametric Mann Whitney test revealed a significant difference for neutral/relaxed adverbial facial expressions ($U=32.5$, $p<.05$) (Median: ASD: 5, control: 10) with controls producing significantly more neutral/relaxed adverbials. However both groups did not differ in their production of effortful adverbial facial expressions ($U=52.5$, $p>.05$) (Median: ASD: 13, control: 16.5). A wilcoxon signed ranks test was conducted for within group differences in scores for the two adverbial types 'neutral/relaxed' and 'effortful'. Both groups showed significantly higher scores for effortful adverbials (ASD: $Z=-2.8$, $p<.05$, control: $Z=-3.1$, $p<.05$). This suggests that the main difference between groups in adverbial facial expression production is in the use of neutral/relaxed adverbials.

Figure 9:24: Example of a control participant producing an identical ‘effortful’ adverbial facial action for MAN CARRY WEIGHT INT

Figure 9:25: Example of a deaf individual with ASD producing a blank ‘effortful’ adverbial facial action for MAN CARRY WEIGHT INT

Figure 9:26: Example of a deaf individual with ASD producing a blank ‘effortful’ adverbial facial action for MAN CARRY WEIGHT INT

Figures 9:24-9:26 qualitatively demonstrate that individuals with ASD produce adverbial facial actions differently to controls. Figure 9:24 shows an individual from the control group producing MAN CARRY WEIGHT INT. If this facial action is compared with those that are produced by the two participants in the ASD group (see Figures 9:25 and 9:26) for the same item the deaf individuals with ASD have markedly flatter, less expressive facial actions.

Discussion

The deaf ASD group produced fewer adverbial facial actions compared to controls. This finding was in line with the hypothesis. Qualitative differences between groups (identical, similar and miscellaneous) did not reach significance, however the deaf ASD group did show a selective impairment in production of adverbial expressions with less exact approximation to target facial actions (e.g. greater instances of 0 facial actions being produced), when this was further analysed the deficit appeared to be more pronounced with

‘neutral/relaxed’ adverbials (e.g. MM). These findings are in line with McIntire and Reilly (1988) who found that adverbials are produced less by hearing learners compared to other linguistic and affective facial expressions, particularly with the adverbial MM. It is possible that the deaf ASD group did not differ on production of effortful adverbial facial expressions because making effort is more mandatory than marking relaxed manner in BSL and the latter is more easily overlooked in production by non-native signers (McIntire & Reilly, 1988).

These findings are not consistent with a similar production task using picture stimuli in experiment 5c (negation), which demonstrates a comparable number of negation facial acts produced between both groups. This lends further support to the idea that adverbials are different in function to negation NMMs.

One interesting parallel with the current findings and those from experiment 5c is the impairment with producing structures that rely on mouth action. Deaf individuals with ASD produced less mouth actions compared with eyebrow and head shake actions for negation targets in experiment 5c. Although differences in general language ability have been controlled through matching on BSL tasks, no measure was taken of participants’ use of English mouthing during production. It is possible that some members of the ASD group may have used English mouthings to a greater extent than controls. The use of English mouthings precludes the use of facial adverbials. If signers use more SSE, this would in turn result in fewer adverbials and other non-manual uses of the mouth (e.g. the downturned lips seen in negation), as it is not possible to use adverbials and English mouth patterns at the same time (Emmorey et al., 2008). While this is often seen in healthy signers

and is not by definition pathological, it is also possible that English mouthing is used as a strategy where BSL devices rely on impaired abilities.

A comparison of the complexity of the facial actions required to produce an adverbial versus those required to produce other NMMs does not explain poorer performance for adverbials. Adverbials are usually restricted to one feature (e.g. the mouth) whereas questions and negation involve more facial features (e.g. questions use eyebrows, eyes and head tilt and negation uses eyebrows, head shake and mouth).

The difference between findings may be somewhat related to differences in attention and motivation. The ASD participants may have focused on manual signs without incorporating adverbial information about the person's manner (e.g. with the weight lifting adverbial they signed MAN WEIGHT LIFT with flat facial affect). The deaf ASD group may have been capable of appropriate adverbial facial actions but may not have been motivated to describe the actions and behaviours of others, or they may have failed to understand them "children with ASD simply seem disinterested in how you or anyone else might be feeling" (Baron-Cohen et al., 1993, p508). Some participants in the deaf ASD group did not differentiate clearly between photographs when describing them (e.g. they signed MAN LAWNMOWER omitting any references to the manner or effort of the man in both photographs). This explanation is supported by Carpenter (2006, p62) who stated that children with ASD do not copy others' action styles as a "result of a general lack of motivation to share experiences with others".

Another caveat with the methodology used in the production task is the fixed order of presentation of the pictures, if participants were presented with the effortful picture prior

to the neutral/relaxed picture then this may have increased the number of facial actions produced for the neutral/relaxed pictures. This could be further explored in future research.

The current finding sits well with Hobson's argument, adverbial impairments in deaf individuals with ASD may be a result of a more general failure with identifying the psychological orientation of another person. This finding parallels those from Chapter 5 where the deaf ASD group showed impairments in facial expressions describing the actions of others (e.g. mischief). One difficulty with comparing these findings to Hobson's relates to the different methodologies used, Hobson and Hobson (2008) looked at imitation in hearing individuals with ASD, whereas the current task uses production of signs from photo stimuli. In future research with this subgroup it would be of interest to replicate Hobson's task with the deaf ASD group, if they were similarly impaired to hearing individuals with ASD, this would then support the explanation that these tasks have similar requirements.

A weakness with the adverbial production task was that no object related adverbials (e.g. size) were used, if they were used this would be a natural control task for the theory that ToM impairments underpin adverbial deficits in the ASD group. However these size related adverbials do differ from manner adverbials in that they are produced using both the hands and the face. The decision not to include object adverbials was made because it is harder to elicit object adverbials using pictures. It was expected that if participants were shown a photograph of a large object they would be more likely to lexicalise the adverb manually using their hands producing BAG BIG rather than using an adverbial facial action. It is possible that the deaf ASD group would show less of an impairment with producing facial adverbials of this type as they showed reduced impairment with their

comprehension relative to manner adverbials. More thought needs to be given on how to practically design a production task comparing different types of adverbials across the face alone and hands and face, without having a person related association (e.g. showing cartoon shapes which change in size and manner).

Overall discussion

The deaf ASD group have marked selective impairment with both comprehension and production of adverbial facial expressions in BSL. This suggests a general impairment in adverbial use where these are expressed on the face. These findings do not appear to be linked to the task (despite methodological weaknesses), as similar methodologies were used in chapter 7 and no group differences were found for negation.

One limitation is the fact that actions and materials differed across conditions. This is also a criticism that Hobson raised in his imitation experiments, as he used a broad range of stimuli and actions to be imitated (Hobson & Hobson, 2008). Another methodological weakness to consider is the absence of a measure which checked the pre-existing adverbial knowledge of both groups. The deaf ASD group may have not had the various adverbial structures in their linguistic repertoire. Unfortunately it is difficult to ask for or test adverbial knowledge without priming both groups. A parent/teacher checklist such as the MacArthur CDI (Fenson et al., 1993) would have been a useful measure here to determine which adverbials the children had produced or demonstrated an understanding of prior to their participation in the adverbial comprehension and production tasks.

The dissociation between intact negation and impaired adverbials supports the notion that the latter are a distinct linguistic category and supports the argument that they differ due to their communicative substrates. Negation NMMs are different from adverbials

due to their communicative substrates (negation NMMs are seen in spoken language and adverbials are not). McIntire and Reilly (1988) suggest there is a continuum of facial expressions from uniquely emotional (e.g. surprise), to grammatical structures which have overlap with communicative behaviours (e.g. negation, questions) and structures that are unique to the grammar of sign language (e.g. adverbials). The current finding may suggest that deaf individuals with ASD are more impaired with structures unique to sign language (e.g. adverbials), rather than those facial expressions, which originate from spoken language and have a communicative function (e.g. negation and questions). Alternatively it is possible that negation and questions have an intonational function (Reilly et al., 1990; Wilbur, 1991) and adverbials are more syntactic (Liddell, 1980) (although there is little evidence to support this latter claim). However this is opposite to what would be expected given the deficits seen in hearing individuals with ASD and intonation (MacDonald et al., 1989; Ozonoff & Miller, 1996; Peppe et al., 2007). As evidence is mixed regarding the function of different NMMs no firm conclusions can be made.

The fact that comprehension of both adverbials on the face alone and the hands and face were impaired in the deaf ASD group means that a general face processing deficit could not explain the results. Furthermore, the selective nature of the adverbial impairment set against the sparing of other NMMs that also exploit the face further corroborates the notion that general face processing deficits are not an underpinning factor. Rather adverbials uniquely must hinge on other general abilities that are impaired in ASD leading to a selective deficit.

Both the adverbial comprehension and production tasks required identification of the style/psychological motivation of others, this may account for the impairment seen in

deaf individuals with ASD relative to controls on both these tasks. ToM is often impaired in hearing individuals with ASD. Therefore more general ToM impairments associated with ASD may have led to difficulties with using adverbials in BSL. Further research is needed to test these theories, and careful consideration needs to be applied to the design of the task, in order to elicit adverbial facial expressions without relating the tasks to a person and their actions.

By focusing only on manner, we cannot define the exact parameters of the adverbial impairment. It is necessary to further compare the difference between size adverbials and manner adverbials. The finding of impairment with size adverbials in the comprehension task does not fit with the ToM explanation. It is possible that this finding arose due to a generalized impairment with adverbials, possibly relating to a difficulty integrating adverbials on the face with signed information on the hands.

We cannot specify the nature of the adverbial impairment merely from the two experiments which focus on one type of adverbial relating to manner (neutral/relaxed and effortful). From the current chapter it is possible to speculate a model of impairment in the deaf ASD group where they are impaired with adverbials that are related to manner, due to overlaps with ToM and a ToM impairment. However further research needs to be done in order to confirm this hypothesis and rule out other explanations for the adverbial impairment that is seen in the deaf ASD group.

Chapter 10: General results, discussion and conclusion

Results are compared across all studies in this section.

Accuracy scores

Figure 10:1 shows the overall mean accuracy scores across all comprehension tasks in the thesis. The deaf ASD group was significantly impaired relative to controls in the two adverbial conditions (face alone and hands and face). They were surprisingly good at understanding facial expressions in the context of sign language across the rest of the tasks. Overall the lowest performance was in the adverbial and question tasks for both groups, this finding may be related to the later ages of acquisition for both these structures (negation is mastered at the age of 4:0, adverbials at 5:0 and questions at 6:0). All participants were older than these mastery levels, but these later ages of acquisition may reflect the difficulty of the latter two structures. However there were no group differences for question facial expression comprehension.

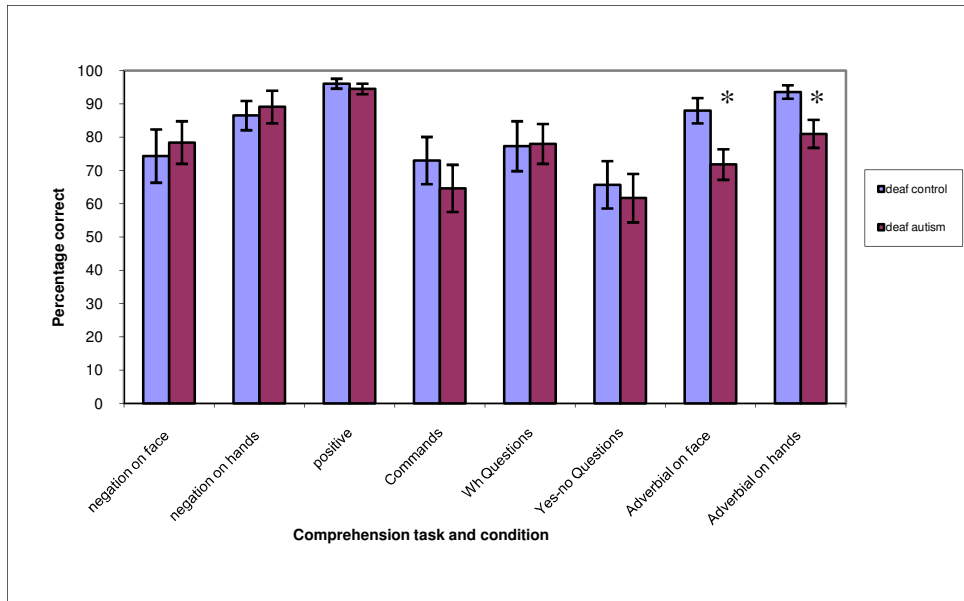


Figure 10:1: Summary graph of mean comprehension scores (%) for linguistic facial expression tasks (* illustrates significant difference between groups)

Figure 10:2 illustrates the quantity of facial expressions that were produced across the different linguistic and affective production tasks for both groups. There was a non-significant trend for the deaf ASD group to produce slightly fewer facial expressions than controls on each of the production tasks. The deaf ASD group was significantly impaired with adverbial production, but on the remaining tasks they had comparable facial expression production to controls. Both groups produced a fairly low range of facial expressions across the tasks, more research needs to be done on facial expression production in deaf adults to determine whether this is the norm.

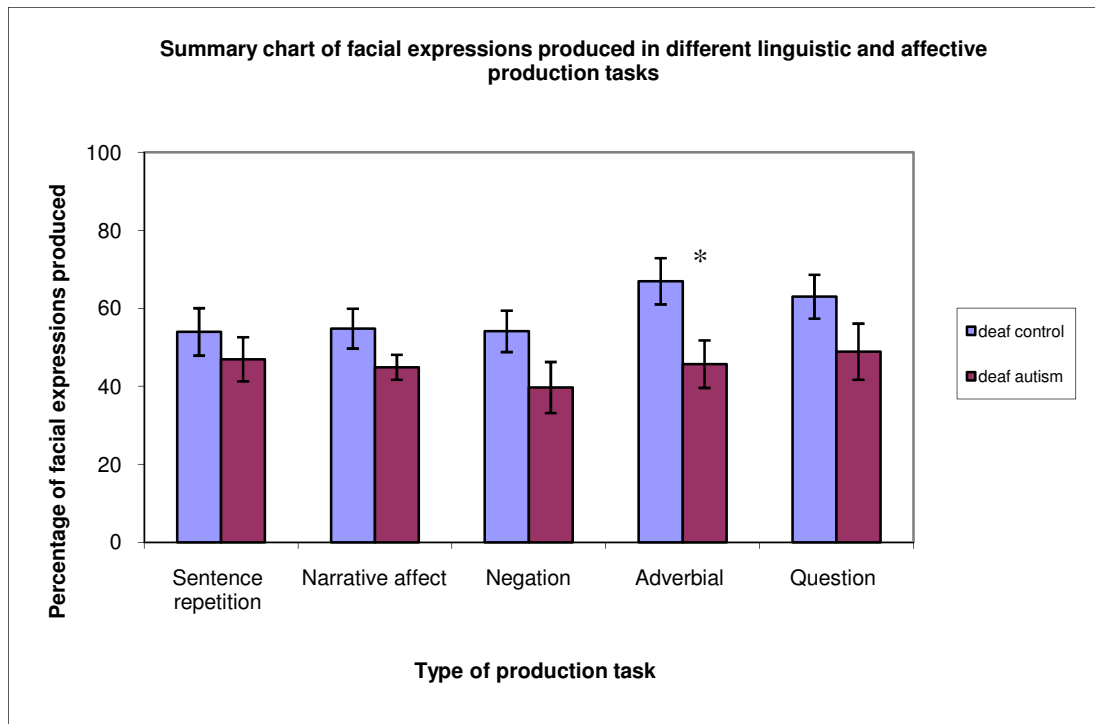


Figure 10:2: Summary graph of mean production scores (%) for linguistic and affective facial expressions (* illustrates significant difference between groups)

Reaction time scores

Only three of the experiments in the thesis looked at reaction time scores between groups for comprehension of facial expressions (experiment 5a, 5b and 7a). All three showed no differences between groups in reaction time.

Non-parametric analyses were mostly used throughout the thesis, as in most cases the data was not normally distributed. This minimised the possibility of type 1 error. For two areas, where significant differences did emerge (e.g. adverbial comprehension or comprehension of mischief) the same differences were also found for production, which strengthened the finding that these two areas were impaired in the deaf ASD group.

Differences in quality of face actions

The deaf ASD group showed some statistically significant differences in facial action quality. Interestingly, they did not significantly differ from controls in the number of facial actions produced (with the exception of adverbial production). However, despite a comparable number of expressions their signing was still qualitatively perceived as different, less fluent or even idiosyncratic.

To summarize, overall results show both groups perform comparably on some tasks (sentence repetition, negation and question comprehension and production) but display important differences on others (recognition and production of specific affective facial expressions, and comprehension and production of adverbials). These findings suggest that face processing abilities are largely preserved in deaf ASD signers, except where these abilities overlap with the ability to process emotions and to make attributions about the mental states of others.

Discussion and conclusion

The overarching aims of this thesis are firstly to investigate whether deaf children with ASD show the general face processing impairments observed in hearing children with ASD and secondly to explore the impact of ASD on the use and understanding of affective and linguistic facial actions within British Sign Language. Findings are critically discussed and broad theoretical explanations are suggested which shed light on theories associated with ASD. The strengths and limitations of the current study are explored and suggested directions for therapeutic intervention and future research are outlined.

Face processing (experiment 1)

Findings from this study indicate that deaf children with ASD differ from hearing individuals with ASD in their face processing ability. In chapter 3, they showed unimpaired face recognition skills on the Benton Facial Recognition test. This contrasts with research reports that hearing groups with ASD are impaired on this measure (Wallace et al., 2008; Annaz et al., 2009). A reduced impairment with face processing in deaf children with ASD was also found by Szymanski and Brice (2008). They used a questionnaire and established that parental ratings much less frequently identified face processing impairments in deaf children with ASD compared to their hearing counterparts (see chapter 1 literature review). Taken together, this evidence may support the experiential hypothesis, namely that the mandatory status of faces for communication may cause the deaf group to attend to faces more than their hearing counterparts throughout their development, subsequently gaining more experience with faces which allows compensation for the autistic tendency to avoid looking at faces or to fail to privilege facial information at neural levels (Klin et al., 2002; Pelphrey et al., 2002; Dalton et al., 2005).

Caution must however be taken with interpreting the lack of face processing impairment identified in this study because a single measure was used which focused exclusively on recognition of faces and did not tap broader aspects of face processing. The measure also used static rather than dynamic face stimuli which may overlook impairment with moving, rapidly changing faces and a hearing ASD control group was not recruited. Furthermore, findings relating to the BFRT in hearing people with ASD have been mixed and a number of methodological problems have been reported. Despite these caveats, it is important to note that the deaf ASD group in this study did not show gross inability to

produce and comprehend facial expressions in BSL. In fact, face related aspects of BSL grammar on the whole were remarkably preserved suggesting that face processing is not substantially impaired in these signers. Additionally, contrary to expectation given their diagnosis of ASD, deaf children did not show qualitative difficulty with attending to faces for the purpose of communication. These findings suggest that face processing and attention to faces are not central deficits of ASD but rather manifest in hearing people, as an indirect consequence of other impairments which are core to ASD. Thus, impairments in face processing are likely to arise during development unless compensatory conditions exist such as deafness, which makes attention to faces more mandatory. Arguably these conditions could be simulated for hearing children with ASD by exposure to purely signed communication without simultaneously speech input since then the child would have to watch the face of their communication partner. However, until the issue of whether exposure to faces improves face processing or whether auditory deprivation in deaf children also has a contributory role, is resolved (McCullough & Emmorey, 1997), assertions about the mechanisms for relative preservation of face processing in deaf individuals with ASD cannot be absolute.

Affective facial expressions in sign language (experiments 2- 4)

Facial actions in the context of sign language were explored in detail. Chapters 4 and 5 focused on emotional expressions which convey affective meaning in BSL sentences. Chapters 7-9 investigated linguistic facial actions which allow the non-manual marking of questions, negation and adverbial structures. Interestingly, the deaf ASD group showed greater impairments with affective facial actions than those with purely linguistic function. The uneven sparing of some uses of the face in BSL provides further evidence that there is

no global impairment with faces. The pattern of results points instead to more general impairments with emotional understanding which mediates poor performance where the face is used to express emotions but not where linguistic information is conveyed. This is unsurprising given that deficits in emotional understanding are central to the autistic phenotype.

The deaf ASD group in this study showed substantial impairment with understanding and producing emotional facial actions. During comprehension tasks, in Chapter 4 they had a spared ability to understand ‘neutral’, ‘surprise’, ‘annoyed’, ‘disgust’ and ‘sadness’ but were impaired at recognising expressions conveying ‘mischief’, ‘happiness’ and ‘anger’. Furthermore, subtle patterns relating to specific emotions emerged which are revealing. In chapter 5, the group had specific difficulty with producing expressions of ‘mischief’ and ‘demand’ in a narrative task. It was hypothesized that the specific difficulty with ‘mischief’ could be explained by a super ordinate impairment in mental reasoning and ToM. Chapter 6 recorded fewer affective expressions in an imitation task relative to linguistic expressions in both groups.

Linguistic facial expressions in sign language (experiments 4-9)

Linguistic facial actions were also informative, with broadly preserved ability but a striking dissociative impairment of adverbials. This suggests that the deaf ASD group do not have a uniform deficit with linguistic facial expressions in sign language. In chapter 6 both groups had similar performance when imitating both affective and linguistic facial expressions in a BSL sentence repetition test, making a similar number of omissions. However, the facial actions of the deaf ASD group differed in quality, less closely approximating modelled linguistic facial expressions. Chapters 7-8 showed the deaf ASD group performed on a par

to controls in their use of linguistic facial expressions. Chapters 7 and 8 revealed that the use and understanding of non-manual structures marking negation and questions were wholly unimpaired in the deaf ASD group. Impressively, the quantity and quality of productions did not differ from matched controls. The most striking linguistic finding was that the deaf ASD group showed dissociation between grossly impaired performance with adverbials and preserved ability with other facially expressed structures in BSL. The selective deficit was documented in Chapter 9. Comprehension of adverbial facial expressions was significantly reduced in the deaf ASD group and production was also impaired, with fewer adverbial facial actions. However, productions, when they did occur, did not differ in quality to those produced by controls.

Overall the deaf ASD group was not dramatically impaired with the use of facial expressions in sign language, demonstrating similar communication skills to the typically developing deaf control group. It is striking that these findings occurred, as it was expected that the deaf ASD group would do badly on a majority of the tasks due to an aversion to faces normally observed in hearing children with ASD. Rather, they showed a unique set of impairments relative to the control group, which suggest that other impairments associated with ASD rather than a face processing deficit per se are responsible for these findings.

Theoretical explanations

The findings of the current study do not support the notion of primary impairment with face processing directly impacting on use of the face in BSL. Instead, it is suggested that underlying deficits in two key areas associated with ASD can explain patterns of spared and impaired abilities in deaf signers with ASD. Firstly deficits in emotional understanding would account for broad impairment of affective facial actions in BSL, thus it is a primary

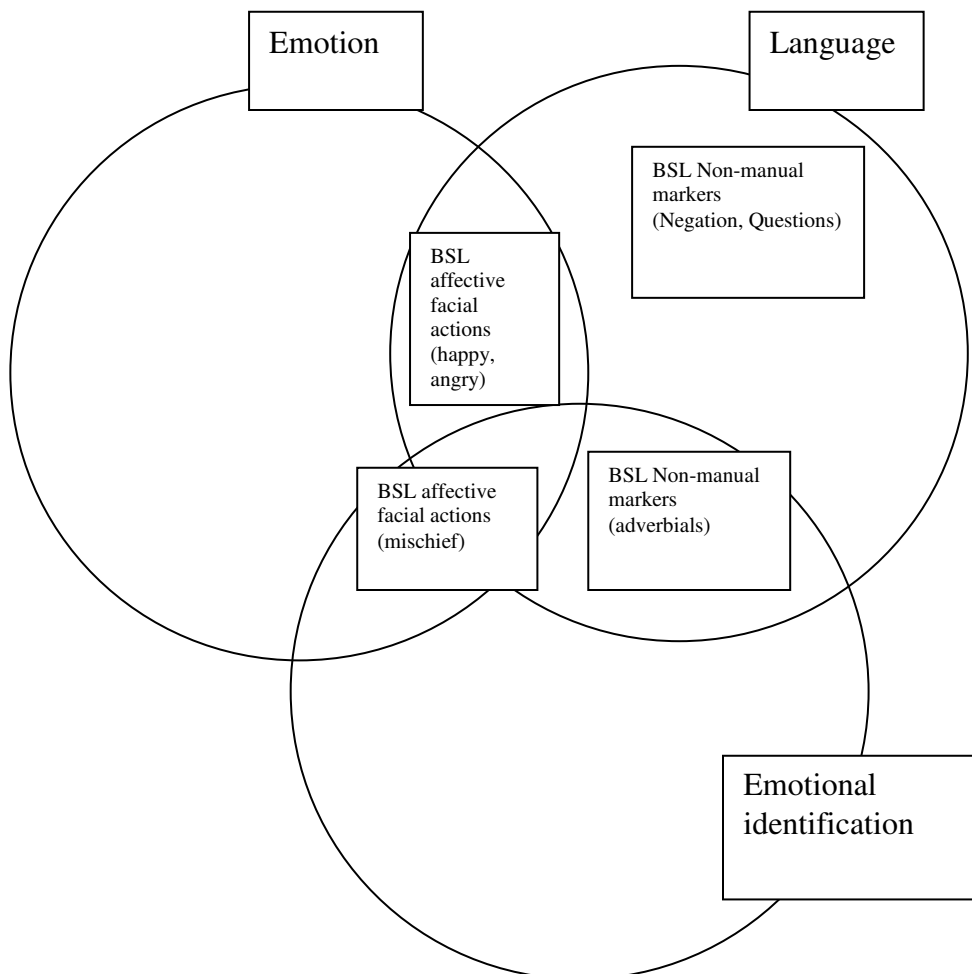
impairment with emotional processing that mediates the ability to comprehend and produce affective facial expressions rather than deficient face processing ability. This account would be strengthened by findings that the same signers were impaired with emotion tasks that were free of language. Therefore it would be necessary to further explore this hypothesis by giving both groups a faces task that is less dependent on language skill (e.g. Ekman & Friesen's 1976, emotion from faces task).

Secondly, it is proposed that a general impairment in ToM accounts for difficulties with adverbials, since these require the understanding of the mental states of others. The hypothesized overlap between prerequisite abilities is diagrammatically depicted in Figure 10:3. Impaired aspects of BSL fall within the deficient emotional and ToM domains. By contrast facially marked aspects of BSL are preserved where they do not rely on intact emotion processing or ToM ability (e.g. questions and negation). Furthermore, within the affective domain the most pronounced impairments are for emotions that require attributions about *both* emotional meaning and the mental state of others (e.g. mischief).

This hypothetical model does not imply modular neural organization (Fodor, 1968). Smith et al., (2003) proposed quasi-modules for ToM and social deficits stating that all components can dissociate with each other in ASD. This model instead conceptualizes the prerequisite abilities required for non-manual, facially expressed aspects of BSL, which are partially but not wholly impaired in ASD. Support for this model comes from the large body of evidence that gross impairments in both emotional understanding (Capps et al., 1992; Baron-Cohen et al., 1993; Grossman & Tager Flusberg, 2008; Lacroix et al., 2009; Rump et al., 2009; Volker et al., 2009) and ToM (Baron-Cohen et al., 1985; Leslie & Frith, 1987; Frith 1989; Leslie & Happe, 1989) are central to the autistic phenotype. Thus, it

comes as no surprise that these deficits in deaf signers with ASD will cause subtle selective impairment of the aspects of BSL that hinge on these abilities. The more surprising fact that facial aspects of BSL are wholly preserved where they do *not* rest on these abilities indicates that emotional understanding and ToM are the primary impairments in ASD and face processing should be seen as a secondary deficit at least to some extent, which can be ameliorated by exposure to a signed language.

Figure 10:3: Diagrammatic representation of impaired and unimpaired facial actions in BSL in deaf individuals with ASD (intersections represent impaired abilities)



There are two caveats that this model cannot account for:

- 1) Impairment with adverbials relating to size (e.g. in the hands+face condition in the adverbial comprehension task). However it is noted that the impairment with hands+face (size) related adverbials was significantly lower than the impairment with face alone adverbials (relating to manner). It is possible that a propensity towards avoiding adverbials used in general in sign language developed from a difficulty with use of adverbials relating to manner. More research needs to be done with a broader range of adverbials to contrast items requiring ToM with those that do not to validate this hypothesis.
- 2) A ToM explanation cannot fully explain impairments with affective facial expressions in the deaf ASD group as emotions are differently impaired across tasks (e.g. happy and angry are impaired in the emotion comprehension task) these emotions appear to be less demanding of ToM relative to mischief. A greater exploration of the types of emotion that are impaired in the deaf ASD group (both within the context of sign language and without language requirements) would be necessary to establish the causality behind these emotional impairments. Nevertheless a ToM account is appealing as difficulties with mentalising (i.e. understanding another person's mental state) would explain specific impairments with facially expressions connoting 'demand', 'mischief' and adverbials reflecting the manner in which an actor is carrying out an action, or experiencing something. However, a major weakness with the findings and their application to this model is the fact that ToM ability was not explicitly tested and there is no correlational data available which would allow the mapping of ToM deficits to the pattern of impairments in BSL facial actions. Furthermore, it is difficult to tease out the influence of ASD from that of deafness and inadequate language exposure since typically developing deaf children

from hearing families often show delayed or impaired development of ToM (Courtin, 2000; Marschark et al., 2000; Peterson & Siegal, 2000; Woolfe et al., 2002; Peterson et al., 2005; Brown, 2007; Shick et al., 2007; Peterson & Wellman, 2009). This is in contrast to deaf children from deaf families who pass ToM tasks at a similar age as hearing children (Woolfe et al., 2002). Detailed information about the ToM ability of both groups was not formally tested, however given their age it is expected that the control group would have acquired ToM. Marschark et al., (2000) demonstrated that deaf non-native signers aged between 9-15 years old were capable of attributing mental states to others as well as themselves. The minimum age for participants in both groups was 8:5 (one participant in the deaf control group, the rest were all 9:0 and above), therefore on the basis of Marshark's findings it is likely that all the deaf controls at least should possess ToM. It is not known how the ToM ability of individuals with autism is influenced by the presence of both autism and deafness. The causal mechanisms are clearly different for deaf children and those with ASD. The former acquire ToM at a later age than hearing children or native signers, due to impoverished language exposure, whereas the latter have disrupted ToM due to a more basic cognitive or neurological deficit. "Deaf children show a specific delay in language skill...they have no neurological abnormality, which seems responsible for ToM impairment in children with autism" (Hao et al., 2010, p1491). Non-verbal violation of expectation tasks, using eye tracking to monitor attention to a cartoon character's false beliefs, further demonstrate that this impairment is more than just language based in hearing individuals with ASD (Senju et al., 2009). Similar non-verbal eye tracking tasks have been administered to oral deaf children (Figueras & Harris, 2001) and deaf children of hearing parents (Morgan, 2010). These studies may help to further separate out the nature

of ToM impairments in both groups. However simple false belief tasks can be a crude way of measuring ToM ability, so a variety of measures should be used to fully establish the ToM skills of deaf children with ASD. Therefore due to a number of erroneous findings and a lack of further research, this model at present is speculative at best.

Alternative theories of ASD

Perspective taking

The current findings support Shield's (2010, p2) notion that "sign language forces learners to employ cognitive skills thought to be impaired in autism". Shield (2010) demonstrated that deaf children with ASD show phonological impairments in their sign production, they do not rotate signs which are mirrored for signer perspective (see chapter 1 for further details). Shield proposed Hobson's theory (Hobson, 1984; Hobson & Lee, 1999; Hobson & Hobson, 2007) to account for his findings, where the ability to '*identify with others*' is impaired in deaf individuals with ASD (see chapter 9 discussion for more details). More research is needed to clarify how Hobson's early social and affective impairments link to ToM, as Hobson stated that impairments characteristic of ASD appear due to social and emotional impoverishment, where social emotional difficulties are the major deficit in ASD and they lead to ToM impairments. Potentially both of these explanations (ToM or '*identifying with others*' due to social and emotional difficulties) can account for the impairments seen in the deaf ASD group. This possibility has been left open by the inclusion of the term '*emotional identification*' in Figure 10:3.

Mirror neuron theory

One recent theory attempting to account for impairments in ASD suggests a core underlying deficit in the functioning of mirror neurons (Dapretto et al., 2006; Oberman & Ramachandran, 2007) (see chapter 1 for further details). MNS dysfunction has been implicated in difficulties with action interpretation, ToM, language and empathy, however the biggest deficit that is associated with MNS dysfunction in individuals with ASD is imitation (Southgate & Hamilton, 2008). In the current study the deaf ASD group had difficulties with action interpretation (with description of character's actions in narrative e.g. mischief and demand in chapter 5 and adverbial comprehension and production in chapter 9). The deaf ASD group also appeared to have difficulties with ToM ability (through impaired comprehension and production of certain emotions that are thought to have links with ToM in chapters 4 and 5) although ToM was not formally tested in both groups. Mirror neuron theory has been questioned regarding its ability to account for all the deficits associated with ASD (Southgate & Hamilton, 2008). This is largely true for the current findings too, with a number of inconsistencies: the deaf ASD group had unimpaired imitation relative to controls (in Chapter 6), their language was comparable between groups as shown by similar comprehension in BSLRST, negation and question tasks) and empathy was not tested so conclusions regarding the deaf ASD group's empathizing skills cannot be made. Therefore on the basis of these preservations (largely the unimpaired imitation ability of the deaf ASD group) and weaknesses associated with mirror neuron theory in ASD (Southgate & Hamilton, 2008), mirror neuron theory alone cannot account for these findings that were specific to the deaf ASD group.

Methodological strengths

There are a number of strengths to this thesis.

1) It is based on a unique, and understudied, group of deaf children with ASD and makes a significant contribution to a small but growing literature on this population. This is the first study to systematically investigate facial expression comprehension and production in a signed language with deaf signers with ASD. “There are few studies which examine developmentally atypical sign language” (Penn et al., 2007, p372).

2) Detailed measures were developed and documented that can easily be replicated.

The measures captured the ability of both typically developing signers and signers with ASD as neither group scored at floor or ceiling.

3) Video evidence has been collected (with corresponding ethical approval), which may allow professionals working with deaf individuals with ASD to gain further understanding of their communicative profile.

4) This study is one of the first to ensure that both groups were matched on several measures: chronological age, education type (bilingual environment), non-verbal ability and BSL receptive and productive skills. This level of matching is rarely attained with other specialist groups and it ensured there was a minimal risk of misinterpreting slight variations in the data from the deaf ASD group (Tyrone, 2005).

Methodological weaknesses

The methods that were used to elicit facial expressions in several of the experiments may have been insufficient (e.g. showing photographs and pictures in experiments 5c and 7b), consequently limiting the number of facial expressions that were produced by both groups. It is hard to predict whether or not the control group produced an unusually low number of

productions, as little research has been carried out with deaf children and the production of facial expressions in BSL. Those research studies that do exist are confined to early acquisition stages (e.g. 0-3 years), rather than later on in childhood. All participants were older than the typical age of acquisition for the various facial BSL structures that were tested (e.g. 4:0 for negation, 5:0 for adverbials and 6:0 for questions, Mayberry & Squires, 2006) however these ages are based on acquisition of deaf native signers, there is a lack of research on norms in acquisition for these structures for deaf non-native signers. However the youngest participants were 8:5 and the oldest were 18:0 (mean ages 11-12 for both groups) therefore it is likely that all participants should have had complete mastery for all of these structures that were tested in the thesis.

Other tasks

The use of ‘mischief’ and ‘demand’ as emotional expressions was justified as both expressions involve interpreting the behavior of another person. Hobson (1991) stated that there is too much focus on emotion terms used in emotion recognition tasks, when group differences should be apparent within an ‘affective-personal’ domain. Similarly Tager-Flusberg (1989) found that children with ASD had greater deficits with spontaneous use of words referring to cognitive states (e.g. belief) than emotion words. Therefore these broader emotional/behavioral terms were included in the tasks.

In Chapters 4 and 6, the emotions presented were not made explicit in the manual sign (e.g. HAPPY) this information was only presented non-manually, therefore good language and inferential skills were required for the tasks. In future research the language demands could be reduced somewhat in adaptations of a similar task (i.e. using single signs and

asking participants to judge if the facial expression is congruent or not with the manual sign).

In chapter 5 the narrative used was complex requiring second order knowledge, a simpler narrative may not have led to the errors with facial expressions of mischief and demand that were seen in the deaf ASD group. The absence of a ToM measure means it is not possible to establish whether these findings were specific to ToM or not.

Participants were not specifically told to attend to the face across all comprehension tasks, for the majority of tasks the deaf ASD group were comparable to controls, however for those tasks where differences did emerge between the groups, the lack of explicit instruction to attend to the face may have been an influencing factor. Re-administering the tasks with a different instruction may influence the performance of the deaf ASD group, however practice effects would need to be accounted for.

Sample size and age range

This study had a small sample size (n=13) which limits the generalisability of the findings, however this is an inevitable consequence of working with rare populations. Other group studies recruiting deaf individuals with ASD have similar sample sizes ranging from 9 to 16 participants (Szymanski & Brice, 2008, n=16, Scawin, 2003, n=13, Shield, 2010, n=10, Roper et al., 2003, n=9). Another important consideration was the large age range included in the present sample was 8:5 years to 18:0 years. The relatively low co-occurrence of deafness and ASD in signing deaf children meant that recruitment could not be selective. To ensure that the control group had a similar developmental spread, participants were matched for age and signing ability. Comparable studies have included a large age range

including Szymanski and Brice (2008, range 5-13 years) and Shield (2010, range 4-16 years).

Recruitment and diagnostic uncertainties

The diagnosis of deaf individuals with ASD is fraught with difficulty (see Chapter 1 for further details). The participants in the deaf ASD group came from specialist services, where they were diagnosed by multidisciplinary teams experienced in working with deaf children (e.g. speech and language therapists, psychiatrists and clinical psychologists). However, there is no gold standard for assessing ASD in deaf children and diagnosis is mainly based on clinical intuition and unvalidated questionnaires, and thus may be unreliable. It is possible that the current sample contained children falsely identified as autistic. However, the fact that none of the ASD group performed on a par with their age matched control participants on the Social Responsiveness Scale suggests that diagnosis was sufficient to discriminate between the groups.

High function inclusion bias

This study had an inclusion bias towards children at the higher functioning end of the autistic spectrum. The initial sample included 18 deaf children with ASD, of which five were excluded due to low function or insufficient BSL skills. Two of the remaining thirteen participants had Asperger's Syndrome. These individuals are usually very high functioning with intact language skills (Volkmar et al., 2000). However, a number of studies no longer distinguish between high functioning autism and Asperger's syndrome (Landa, 2000; Klin et al., 2005; Klin, 2006) and recruit both groups (Losh & Capps, 2003; Mazefsky & Oswald, 2007; Paul et al., 2009).

Only high functioning individuals with ASD were recruited to ensure that they had sufficient language skills for testing. This means that these findings have to be treated with some caution, as the results may not generalize to lower functioning deaf individuals with ASD. Overall there were very few outliers suggesting that participants in both groups were uniform in their abilities. More in depth comparisons could have been done within the deaf ASD group comparing the range of SRS scores to give an indication of autism severity.

Group level analysis

Group level study was justified in the current thesis because the focus of investigation was in commonalities in impairment patterns at a group level. However some richer descriptive data may have been overlooked at an individual level for example: communication, style of language and idiosyncratic features of ASD (e.g. echolalia).

Quality of BSL exposure

It was not possible to focus exclusively on native signers due to small numbers in the deaf population (10%) and the rare nature of signers with autism. Therefore the majority of participants in both groups were non-native signers. This study did not control for quality of BSL exposure. All participants were recruited from bilingual schools (12 control participants and five of the deaf individuals with ASD were recruited from the same school) and matched on language ability. This ensured that all participants had some consistency in their language experiences, however participants have had different language experiences prior to school entry. Unfortunately information regarding age and place exposure to sign language (e.g. at home or school) was not collected. Similarly parental communication skill was not investigated. Thus important differences between groups may have been

overlooked. It is possible that deaf individuals with ASD are exposed to less morphologically rich and more directive, concrete BSL with fewer facial expressions. Furthermore, the groups may have differed in the extent to which they used SSE (SSE users communicate using BSL manual signs with English grammar and mouthing, so they have different communication needs to BSL users) rather than BSL forms. It would have been useful to develop some form of measure of this. This would be important to consider, as individuals who prefer SSE are less likely to use adverbials in their facial expression as they substitute English mouthings, hence reduced performance would be attributable to lack of practice rather than impairment. The deaf ASD group may use more SSE than BSL, which would account for their reduced production of adverbial facial expressions. However this explanation would not account for their impaired comprehension and production of specific emotional expressions. The ASD group was able to use BSL in conversational settings and was comparable to the control group, during interaction with the experimenter (a native signer) both groups were equally able to understand BSL.

Implications for diagnosis and intervention

These findings are important both for further understanding the presentation of ASD in deaf children and allowing more accurate diagnostic checklists to be developed for this group, and for broadening our theoretical knowledge of autism in general. Staff at DCYPFS are currently working on improving diagnostic measures for deaf individuals with ASD using the findings from this thesis as a foundation for planning and design. By identifying impairments in sign language that are associated with deaf individuals with ASD, these findings have highlighted shortcomings of using measures, standardized on hearing individuals with ASD. These measures lack construct validity with deaf children for

example the fact that face processing in deaf signers is much more resilient to impairment than in hearing speakers with ASD means that screening questions focused on general impairment with faces may be misleading. However assertions about face processing cannot be absolute until more detailed measures of broader aspects of face processing are done. Furthermore, therapeutic interventions which focus on experience with faces in the context of social communication may be useful. Indeed this mechanism may be responsible for the improvements reported in hearing children who are exposed to signs as a form of auxiliary communication (Bonvillian et al., 1981). Exposure to sign language in hearing children with ASD may encourage compensatory attention to faces. However, carefully controlled intervention studies are warranted to confirm clinical benefit and also to establish whether simultaneous signing and speech approaches are effective in encouraging attention to the face. It may be that auditory deprivation or being exposure to pure signing without simultaneously voiced speech is the critical factor mediating improved attention to faces in deaf people with ASD, so it remains to be seen if therapeutic strategies could generalize to the hearing ASD population.

This study clearly shows that attention to faces in children with ASD throughout development can prevent more substantial face processing impairments arising due to a lack of experience or practice with faces. This provides optimism and justification for interventions with the general ASD population which creatively encourage looking at the face during everyday interactions.

Like hearing people with ASD, deaf signers appear to have a primary deficit in emotional reasoning and ToM. Additionally, these difficulties are likely to be exacerbated

by factors relating to deafness including impoverished communication environment and language delay. It is therefore recommended that therapies are developed to target these emotional and mentalising competencies and are delivered in accessible linguistically and culturally appropriate ways using BSL. Such therapies could build upon the groundwork down in emotional educational curriculums such as the social and emotional aspects of learning (SEAL), which was implemented by the UK government in 2005 for primary and secondary schools to teach emotional literacy.

Future research

The findings of this thesis are limited by a lack of detailed description of ToM and face processing abilities. These are priorities for future research.

Face processing

Further tests measuring broader face processing skills other than face recognition would be essential to rule out a face processing impairment in the deaf ASD group. Other possible face processing measures that could be used are: Ekman's emotion recognition test (Ekman & Friesen, 1976), tests of featural and configural face processing (Mondloch et al., 2002), dynamic face processing (Tardif et al., 2007) and the bubbles methodology used by (Gosselin & Schyns, 2001). It would also be invaluable to use eye tracking with deaf ASD, deaf control and hearing ASD groups to see if deaf individuals with ASD have any differences in patterns of attending to the face that are not demonstrated in general face processing tasks (e.g. the BFRT) or comprehension tasks in sign language. If deaf individuals with ASD and deaf controls did show similar patterns of attending to the face and deaf individuals with ASD were different to their hearing counterparts on the basis of eye tracking, this would strengthen the 'lack of interest' hypothesis.

ToM

It is vital that the deaf ASD group is tested on several measures of non-verbal ToM to confirm the extent of ToM deficit. The magnitude of this impairment should be compared both to typically developing deaf children and hearing children with ASD. This would lend further support to the ToM explanation accounting for the deaf ASD group's impairment with the comprehension and production of mischief. There are a number of suitable ToM tasks which have been used with typically developing deaf children over a range of language abilities. For example the thought bubble false belief task (Woolfe et al., 2002; Morgan & Kegl, 2006) which uses pictorial stimuli to determine whether deaf individuals hold false beliefs about a fisherman's 'catch'. Alternatively Morgan (2010) used an eye-tracking experiment to monitor deaf pre-lingual toddlers' eye movements as they followed a cartoon character on a computer screen in order to establish whether they have false beliefs about a cartoon characters actions. The benefit of this latter methodology is that it is not reliant on language ability.

Detailed investigation of adverbials

- 1) Greater attention needs to be given to a broader range of adverbials covering size and distance information in further experiments. In future more careful thought may need to be given to the task design, so the tasks do not require 'identifying with others' or ToM. This would separate out whether or not the impairments with adverbials and specific emotions are independent of methodological constraints.
- 2) Hobson and Hobson's (2008) imitation task of goal and stylistic actions (see chapter 9 for more details) which demonstrated an impairment with hearing ASD individuals in the imitation of style could be given to the deaf ASD group to

determine whether they are impaired on this task. This would also give an indication of how both groups perform in language free imitation tasks. An impairment in the deaf ASD group on this task would demonstrate how closely related adverbials in BSL and non-linguistic stylistic actions are and this would validate Hobson's theory of 'identifying with others' as an explanation for the deaf ASD group's impairment with adverbials.

Extending existing findings to hearing individuals with ASD

Measuring the performance of a matched group of hearing individuals with ASD on non-language tests in this thesis is necessary to establish whether specific impairments are related to ASD diagnosis in deaf signers. Only some of the experiments in the thesis would be suitable to use with hearing individuals with ASD, as others rely on sentence level comprehension of BSL making them inappropriate (e.g. chapter 4: emotion recognition test, chapter 6: the sentence repetition test and chapter 8: question categorisation test). Deaf and hearing ASD groups could be compared on some of the production measures which did not necessarily require sign language responses (e.g. the question production game of guess who, or the adverbial and negation production tasks). These tasks involve asking questions or describing pictures and they can be done by hearing individuals with ASD using spoken language and production of facial affect, in order to compare any similarities to the deaf ASD group.

In order to separate out effects of deafness and sign language use on individuals with ASD, investigation of hearing individuals with ASD who use sign language is warranted. However one difficulty with this subgroup is that they tend to be lower functioning and have been taught only simple sign language vocabulary rather than as a

language per se due to a failure to develop spoken language. Alternatively oral deaf individuals with ASD who do not use sign language could be recruited, however they are also likely to be lower functioning, as this was found to be the case on the basis of school observations.

Timing and scope

The type of analysis using quantity and quality of facial actions produced relative to deaf adult native signers was consistent with other research studies looking at facial expression use in deaf signers (McIntire & Reilly, 1988). Adam Schembri (a linguist at DCAL who has vast experience with coding and analysis of sign language data) also offered his advice on the best way to develop the coding systems used in this thesis. It would have been informative to refine the coding systems used to explore BSL structures in more detail (e.g. with timing and scope) to look for more subtle deficits that may occur. For example, one of the experienced members of our lab was able to identify which individuals had ASD merely by watching the video-clips of participants signing and producing facial expressions, despite having no knowledge of BSL. This suggests that deaf individuals with ASD do present with autistic mannerisms and unusual use of facial expression which are apparent to non-signing observers. Therefore there were some nuances in their facial expression ability, which are not being detected in the coding system. Kasari et al., (1990) stated that hearing individuals with ASD are impaired in timing and knowing when to use expressions rather than with the production of expressions per se. Similarly Antzakas (2006, p59) stated that “there is a variable relationship between onset and offset of facial actions and manual elements in negation, they are tied to manual part but not precisely”. This timing may be crucially impaired in deaf signers with ASD and this would not have been picked up by

coding focused on quantity and quality of facial actions giving a falsely inferred picture of preserved ability. This hypothesis could be further tested (using the data that has already been collected) by measuring scope and by presenting short video-clips of individuals in both groups producing facial expressions, to raters (who are blind to the experimental group) and asking them to complete an oddity/unusual rating sheet, similar to one that was devised by MacDonald et al., (1989) and Volker et al., (2009). This may demonstrate subtle differences between the two groups in facial expression production. Hobson (1991, p1138) argued that “when testing quality and meaning of autistic children’s expressions... evaluate the subjective experiences of normal people who engage with the children.” Therefore people who are familiar with the deaf ASD individuals (e.g. teachers/ speech and language therapists) could be asked to judge on their facial expression in the same way in order to see if these ratings are any different when given to people who are familiar with them at an individual level.

Conclusions

In conclusion the key findings from this thesis are that deaf children with ASD who use sign language show:

- No evidence of general face processing impairment.
- No difficulties with attending to faces for the purpose of communication.
- Some impairment with affective facial actions in BSL.
- Broad preservation of facial actions in BSL which hold a purely linguistic function, with the notable exception of adverbial non-manual markers.
- Patterns of impairments in both affective and linguistic facial domains which are most pronounced when processing requires attributions about the mental state of others or ToM.
- Differences in the quality of facial actions produced in some production and imitation tasks. Their signing has a qualitatively different feel from that of deaf children without ASD.

These are striking findings given the mandatory status of eye contact for communication to proceed in sign language, the importance of the face for the realisation of grammar and the expectation from observations of hearing children with ASD that attention to faces would be significantly reduced in deaf children with ASD. However the deaf ASD group were not unimpaired with all face processing tasks, they showed a highly specific and subtle pattern of impairments, with deficits in processing of adverbials and certain emotional facial expressions (e.g. mischief).

Appendices

Appendix 1: Example emotion recognition scoresheet (in experiment 2)

1	neutral	angry	sad	happy	surprised	annoyed	disgust	mischief
2	neutral	angry	sad	happy	surprised	annoyed	disgust	mischief
3	neutral	angry	sad	happy	surprised	annoyed	disgust	mischief
4	neutral	angry	sad	happy	surprised	annoyed	disgust	mischief
5	neutral	angry	sad	happy	surprised	annoyed	disgust	mischief
6	neutral	angry	sad	happy	surprised	annoyed	disgust	mischief
7	neutral	angry	sad	happy	surprised	annoyed	disgust	mischief
8	neutral	angry	sad	happy	surprised	annoyed	disgust	mischief
9	neutral	angry	sad	happy	surprised	annoyed	disgust	mischief
10	neutral	angry	sad	happy	surprised	annoyed	disgust	mischief
11	neutral	angry	sad	happy	surprised	annoyed	disgust	mischief
12	neutral	angry	sad	happy	surprised	annoyed	disgust	mischief
13	neutral	angry	sad	happy	surprised	annoyed	disgust	mischief
14	neutral	angry	sad	happy	surprised	annoyed	disgust	mischief
15	neutral	angry	sad	happy	surprised	annoyed	disgust	mischief
16	neutral	angry	sad	happy	surprised	annoyed	disgust	mischief
17	neutral	angry	sad	happy	surprised	annoyed	disgust	mischief
18	neutral	angry	sad	happy	surprised	annoyed	disgust	mischief
19	neutral	angry	sad	happy	surprised	annoyed	disgust	mischief
20	neutral	angry	sad	happy	surprised	annoyed	disgust	mischief
21	neutral	angry	sad	happy	surprised	annoyed	disgust	mischief
22	neutral	angry	sad	happy	surprised	annoyed	disgust	mischief
23	neutral	angry	sad	happy	surprised	annoyed	disgust	mischief
24	neutral	angry	sad	happy	surprised	annoyed	disgust	mischief
25	neutral	angry	sad	happy	surprised	annoyed	disgust	mischief
26	neutral	angry	sad	happy	surprised	annoyed	disgust	mischief

Appendix 2: Binomial tests raw data (used in experiment 2)

The binomial test tool <http://faculty.vassar.edu/lowry/binomialX.html> was used.

Unmasked condition

For the deaf control group significant error confusion patterns consisted of: neutral being significantly mislabelled for sad more often than chance: $n=53$, $k=33$, $p=.125$, $p<.001$, happy being mislabelled for surprise: $n=81$, $k=34$, $p=.125$, $p<.001$, mischief being mislabelled for surprise (with happy subtracted): $n=47$, $k=14$, $p=.125$, $p<.001$, neutral being mislabelled for surprise (with happy subtracted): $n=47$, $k=14$, $p=.125$, $p<.001$, sad being mislabelled for annoyed: $n=67$, $k=14$, $p=.125$, $p<.001$, disgust being mislabelled for annoyed: $n=67$, $k=14$, $p=.125$, $p<.001$, annoyed being mislabelled for disgust: $n=86$, $k=33$, $p=.125$, $p<.001$, sad being mislabelled for disgust (with annoyed removed): $n=53$, $k=19$, $p=.142$, $p<.001$ and mischief being mislabelled as disgust: $n=34$, $k=17$, $p=.125$, $p<.001$. Sad for neutral: $n=53$, $k=22$, $p=.125$, $p<.001$, annoyed for angry: $n=31$, $k=11$, $p=.125$, $p<.001$ and happy for mischief: $n=31$, $k=17$, $p=.125$, $p<.001$.

For the deaf ASD group significant error confusion patterns consisted of: surprise being mislabelled for happy; $n=67$, $k=18$, $p=.125$, $p<.001$, neutral being mislabelled for sad: $n=74$, $k=26$, $p=.125$, $p<.05$, annoyed is confused with sad (with neutral subtracted): $n=34$, $k=13$, $p=.142$, $p<.001$, sad is confused with neutral: $n=74$, $k=35$, $p=.125$, $p<.001$, happy is confused with surprised: $n=72$, $k=31$, $p=.125$, $p<.001$, annoyed is mislabelled to angry: $n=69$, $k=31$, $p=.125$, $p<.001$. Neutral is mislabelled as angry (with annoyed removed): $n=38$, $k=15$, $p=.142$, $p<.001$, happy is mislabelled as annoyed: $n=72$, $k=21$, $p=.125$, $p<.001$, disgust is mislabelled as annoyed (with happy removed): $n=44$, $k=13$, $p=.142$, $p<.001$.

Annoyed is mislabelled as disgust: $n=82$, $k=31$, $p=.125$, $p<.001$. Sad is mislabelled as disgust (with annoyed removed): $n=51$, $k=18$, $p=.142$, $p<.001$. Surprise is mislabelled as mischief: $n=72$, $k=21$, $p=.125$, $p<.001$, happy is mislabelled as mischief (with surprise removed): $n=51$, $k=17$, $p=.142$, $p<.001$ and neutral is mislabelled as mischief (with surprise and happy removed): $n=34$, $k=15$, $p=.167$, $p<.001$.

Masked condition

For the deaf control group significant error confusion patterns consisted of: neutral and surprise for happy: $n=90$, $k=18$, $p=.125$, $p<.001$, annoyed for happy: $n=72$, $k=15$, $p=.142$, $p<.001$. Happy for sad: $n=82$, $k=23$, $p=.125$, $p<.001$, neutral for sad: $n=59$, $k=18$, $p=.142$, $p<.001$ and annoyed and disgust for sad: $n=41$, $k=15$, $p=.167$, $p<.001$. Annoyed for neutral: $n=67$, $k=26$, $p=.125$, $p<.001$ and happy for neutral: $n=41$, $k=17$, $p=.142$, $p<.001$. Disgust for surprise: $n=95$, $k=26$, $p=.125$, $p<.001$, sad for surprise: $n=69$, $k=16$, $p=.142$, $p<.001$, annoyed and angry for surprise: $n=53$, $k=15$, $p=.167$, $p<.001$ and neutral for surprise: $n=38$, $k=13$, $p=.02$, $p<.001$. Happy for angry: $n=67$, $k=18$, $p=.125$, neutral and annoyed for angry: $n=49$, $k=15$, $p=.142$, $p<.001$. Angry for annoyed: $n=74$, $k=18$, $p=.125$, surprise for annoyed: $n=56$, $k=17$, $p=.142$, $p<.001$ and disgust for annoyed: $n=39$, $k=13$, $p=.167$, $p<.001$. Sad for disgust: $n=95$, $k=31$, $p=.125$, $p<.001$, annoyed for disgust: $n=64$, $k=23$, $p=.142$, $p<.001$ and happy for disgust: $n=45$, $k=16$, $p=.167$, $p<.001$. Neutral for mischief: $n=90$, $k=23$, $p=.125$, $p<.001$, happy for mischief: $n=67$, $k=15$, $p=.142$, $p<.001$ and sad for mischief: $n=52$, $k=13$, $p=.167$, $p<.001$.

For the deaf ASD group significant error confusion patterns consisted of: sad for happy: $n=86$, $k=17$, $p=.125$, $p<.001$, neutral for sad: $n=78$, $k=31$, $p=.125$, $p<.001$, happy for sad:

n=47, k=19, p=.142, p<.001, annoyed for sad: n=28, k=14, p=.167, p<.001. Happy for neutral: n=64, k=22, p=.125, p<.001, sad for neutral: n=42, k=17, p=.142, p<.001 and mischief for neutral: n=25, k=11, p=.167, p<.001. Sad for surprise: n=97, k=25, p=.125, p<.001, neutral and annoyed for surprise: n=72, k=19, p=.142, p<.001 and disgust for surprise: n=53, k=17, p=.167, p<.001. Annoyed for angry: n=53, k=17, p=.125, p<.001 and sad for angry: n=36, k=11, p=.142, p<.001. Angry for annoyed: n=78, k=28, p=.125, p<.001, disgust for annoyed: n=50, k=17, p=.142, p=.001 and sad for annoyed: n=33, k=11, p=.167, p<.001. Sad for disgust: n=94, k=33, p=.125, p<.001, annoyed for disgust: n=61, k=19, p=.142, p<.001, happy for disgust: n=42, k=14, p=.167, p<.001 and neutral and angry for disgust: n=28, k=11, p=.02, p<.001. Happy for mischief: n=82, k=22, p=.125, p<.001 and sad for mischief: n=60, k=14, p=.142, p<.001.

Appendix 3: Example BSLNST scoresheet

Assessing British Sign Language Development: Production Test (Narrative Skills)

Score Sheet

Child's name [REDACTED]
 Age [REDACTED]
 Date of birth [REDACTED]
 Date of test [REDACTED]
 Tester [REDACTED]
 Comments [REDACTED]

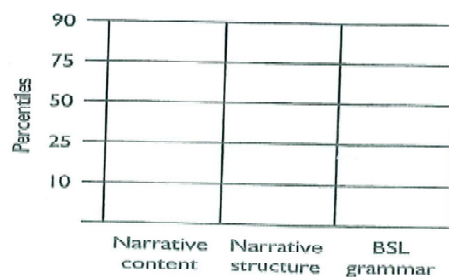
Scoring narrative content

Narrative content 15 /16
 Questions 4 /6
 Total for narrative content 19 /22
 Total for narrative structure 12 /12

Scoring BSL grammar

Spatial verbs 11 /12
 Agreement verbs 4 /4
 Aspect 5 /5
 Manner 1 /5
 Role shift 3 /4
 Total for BSL grammar 24 /30

Graph of subtest results



Keep in touch with our research

The authors intend to standardise the BSL Production Test once data on more children is available. You can assist with this process by sending in completed score sheets from children you have tested. All information received will be treated in strictest confidence. Please fill in a questionnaire to accompany each score sheet. Send score sheets and questionnaires to:

Dr Rosalind Herman
 Department of Language & Communication Science
 City University, Northampton Square
 London EC1V 0HB
 Thank you

Photocopying of this score sheet by the purchaser is permitted

© Herman et al. 2005

Appendix 4: List of items and trials for experiment 5b, (the BSL test of negation comprehension, masked and unmasked trials

Videoclip name	Image 1-left	Image 2-right	right answer	location of right answer	stimulus type	Trial
bread neg1	Bread	bread2	bread2	right	Face	Practice
bite nothing1	Chase	chase 2	chase	left	Manual	Practice
car crash neg1	crash2	crash	crash	right	Face	Practice
door open1	door2	door	door	left	positive	Practice
feed neg1	Feed	feed2	feed2	right	Face	Practice
kick neg1	football	football 2	football	left	Face	Practice
ship sink nothing1	ship2	ship	ship2	left	Manual	Practice
run1	walk2	walk	walk	left	positive	Practice
fire negs	fire2	fire3	fire2	right	Face	Practice
push negh	push2	push	push2	right	Face	Practice
Bread	bread	bread2	bread	left	positive	HEAD
Bite	chase	chase2	chase2	right	positive	HEAD
car crash	crash2	crash	crash2	left	positive	HEAD
door open	Door	door2	door2	right	positive	HEAD
Feed	Feed	feed2	feed	left	positive	HEAD
Kick	football2	football	football2	left	positive	HEAD
ship sink2	Ship	ship2	ship	left	positive	HEAD
Run	walk2	walk	walk2	left	positive	HEAD
bread neg	bread	bread2	bread	right	Face	HEAD
bite neg	chase	chase2	chase	left	Face	HEAD
car crash neg	crash2	crash	crash2	right	Face	HEAD
door open neg	door2	door	door2	right	Face	HEAD
feed neg	feed2	feed	feed2	right	Face	HEAD
kick neg2	football	football 2	football	left	Face	HEAD
ship sink neg	ship2	ship	ship2	left	Face	HEAD
run neg	walk2	walk	walk2	right	Face	HEAD
bread nothing	bread	bread2	bread	right	Manual	HEAD
bite nothing	chase	chase2	chase	left	Manual	HEAD
car crash nothing	crash	crash2	crash	left	Manual	HEAD
door open nothing	Door	door2	door	left	Manual	HEAD

feed nothing	feed2	feed	feed2	left	Manual	HEAD
KICK nothing	football	football 2	football	left	Manual	HEAD
ship sink nothing	Ship	ship2	ship2	right	Manual	HEAD
run nothing	walk2	walk	walk	right	Manual	HEAD
Breads	bread	bread2	bread	left	positive	FACE
Bites	chase	chase2	chase2	right	positive	FACE
car crashes	crash2	crash	crash2	left	positive	FACE
door opens	Door	door2	door2	right	positive	FACE
Feeds	Feed	feed2	feed	left	positive	FACE
Kicks	football2	football	football2	left	positive	FACE
ship sink2s	Ship	ship2	Ship	left	positive	FACE
Runs	walk2	walk	walk2	left	positive	FACE
bread negs	bread2	bread	bread	right	Face	FACE
car crash negs	crash	crash2	crash2	right	Face	FACE
door open negs	Door	door2	door2	right	Face	FACE
feed negs	Feed	feed2	feed2	right	Face	FACE
ship sink negs	ship2	ship	ship2	left	Face	FACE
run negs	walk2	walk	Walk	right	Face	FACE
bite negs	chase	chase2	chase	left	Face	FACE
kick negs	football	football 2	football	left	Face	FACE
bread nothings	bread	bread2	bread2	right	Manual	FACE
bite nothings	chase	chase2	chase	left	Manual	FACE
car crash nothings	crash	crash2	crash	left	Manual	FACE
door open nothings	Door	door2	Door	left	Manual	FACE
feed nothings	feed2	feed	feed2	left	Manual	FACE
KICK nothings	football	football 2	football	left	Manual	FACE
ship sink nothings	Ship	ship2	ship2	right	Manual	FACE
run nothings	walk2	walk	Walk	right	Manual	FACE
Breadh	bread	bread2	bread	left	positive	HANDS
Biteh	chase	chase2	chase2	right	positive	HANDS
car crash	crash2	crash	crash2	left	positive	HANDS
Feedh	Feed	feed2	Feed	left	positive	HANDS
Kickh	football2	football	football2	left	positive	HANDS
ship sink2h	Ship	ship2	Ship	left	positive	HANDS
door openh	Door	door2	Door	right	positive	HANDS
Runh	walk2	walk	walk2	left	positive	HANDS
bread negh	bread	bread2	bread2h	right	Face	HANDS
car crash negh	crash2	crash	crash	right	Face	HANDS

door open negh	door2	door	Door	right	Face	HANDS
feed negh	Feed	feed2	feed2	right	Face	HANDS
ship sink negh	ship2	ship	ship2	left	Face	HANDS
kick negh	football	football 2	football	left	Face	HANDS
bite negh	chase	chase2	chase	left	Face	HANDS
run negh	walk2	walk	Walk	right	Face	HANDS
bread nothingh	bread	bread2	bread2	right	Manual	HANDS
bite nothingh	chase	chase2	chase	left	Manual	HANDS
car crash nothing	crash	crash2	crash	left	Manual	HANDS
door open nothing	Door	door2	Door	left	Manual	HANDS
feed nothingh	feed2	feed	feed2	left	Manual	HANDS
KICK nothingh	football	football 2	football	left	Manual	HANDS
ship sink nothing	Ship	ship2	ship	right	Manual	HANDS
run nothing	walk2	walk	walk2	right	Manual	HANDS

Appendix 5: Example coding sheet for experiment 5c, the negation production test

Negation production test:

Tier 1: Sentence- Positive/Negative P,N

Tier 2: Negpres Y,N,N/A

Tier 3: Targets:

Head shake /1

Furrowed eyebrows/raised eyebrows /1

downturned lips/pursed lips /1

Each item /3

Appendix 6: List of the questions and commands used in experiment 6a (not in testing order) (question categorisation test)

Signed instruction	Sentence type
CIRCLE TRIANGLE NEXT	Command
SQUARE SQUARE NEXT	yes-no question
SQUARE SQUARE ON	yes-no question
BLUE RED ON	Command
BLUE RED ON	yes-no question
BLUE CIRCLE RED CIRCLE ON	Command
BLUE CIRCLE RED CIRCLE ON	yes-no question
BLUE HOW MANY	Wh question
BLUE SQUARE BLUE CIRCLE ON	Command
BLUE SQUARE ORANGE SQUARE UNDER	Command
BLUE SQUARE ORANGE SQUARE UNDER	yes-no question
CIRCLE HOW MANY	Wh question
CIRCLE SQUARE NEXT	Command
CIRCLE SQUARE NEXT	yes-no question
CIRCLE TRIANGLE NEXT	yes-no question
CIRCLE TRIANGLE NEXT	Command
CIRCLE TRIANGLE ON	Command
CIRCLE TRIANGLE ON	yes-no question
HOW MANY	Wh question
ORANGE HOW MANY	Wh question
ORANGE ORANGE ON	Command
ORANGE ORANGE ON	yes-no question
ORANGE SQUARE WHICH NEXT	Wh question
ORANGE TRIANGLE WHICH NEXT	Wh question
ORANGE TRIANGLE WHICH UNDER	Wh question
RED CIRCLE WHERE	Wh question
RED TRIANGLE ORANGE CIRCLE UNDER	yes-no question
RED HOW MANY	Wh question
RED TRIANGLE ORANGE CIRCLE UNDER	Command
RED TRIANGLE ORANGE TRIANGLE ON	Command
SQUARE ON 2 CIRCLE	Command
SQUARE ON 2 CIRCLE	yes-no question
SQUARE CIRCLE NEXT	Command
SQUARE CIRCLE NEXT	yes-no question
SQUARE HOW MANY	Wh question
SQUARE SQUARE NEXT	Wh question
SQUARE SQUARE ON	Command

SQUARE TRIANGLE ON	Command
SQUARE TRIANGLE ON	yes-no question
TRIANGLE CIRCLE UNDER	Command
TRIANGLE CIRCLE UNDER	yes-no question
TRIANGLE HOW MANY	Wh question
TRIANGLE SQUARE ON	yes-no question
TRIANGLE SQUARE UNDER	Command
WHICH UNDER	Wh question
TRIANGLE SQUARE ON	Command
TRIANGLE SQUARE UNDER	yes-no question
BLUE SQUARE BLUE CIRCLE ON	Command
RED TRIANGLE ORANGE CIRCLE UNDER	Command
RED TRIANGLE ORANGE SQUARE UNDER	Command
RED TRIANGLE ORANGE TRIANGLE ON	Command

Appendix 7: video-clips and pictures used in experiment 7a (adverbial comprehension test)

ITEM	Facial adverbial	picture left	picture right	location of right answer	trial type
dog big	CHA	dog small	dog big	right	Practice
Pizza thick	CHA	pizza thick	pizza thin	left	Practice
big pile money	CHA	big pile money	small pile money	left	Test
car tree fall	INT	car	car tree fall	right	Test
Clean 4	INT	clean effort	Clean	left	Test
Clean2	MM	clean effort	Clean	right	Test
Crowd	INT	Crowd	Empty	left	Test
dog small	PS	dog small	dog big	left	Test
Fat	PUFF	Thin	Fat	right	Test
icecream big	CHA	Icecream small	icecream big	right	Test
icecream small	PS	icecream small	icecream big	left	Test
laptop thin	PS	laptop	laptop thin	right	Test
lightbulb bright	NEUTRAL	lightbulb bright	Lightbulb	left	Test
Lightbulb	INT	lightbulb bright	Lightbulb	right	Test
man balloon 5	NEUTRAL	balloon	balloon effort	left	Test
man balloon effort2	INT	balloon effort	Balloon	left	Test
man bicycle relax	MM	bicycle effort	Bicycle	right	Test
man bicycle	INT	bicycle	bicycle effort	right	Test
man carry box easy	MM	man carry box	man carry box effort	left	Test
man carry box heavy	INT	man carry box	man carry box effort	right	Test
man climb effort	INT	climb	climb effort	right	Test

man climb	MM	climb	climb effort	left	Test
man dog drag	INT	man walk dog	dog drag	right	Test
man dog walk relax	MM	man walk dog	dog drag	left	Test
man run tired	INT	run	run effort	right	Test
man run	MM	run	run effort	left	Test
man lawnmower effort	INT	lawnmower walk	Lawnmower push 3	right	Test
man lawnmower	MM	lawnmower push 3	Lawnmower walk	right	Test
man typing concentration	INT	man computer	man computer smile	left	Test
man typing looking	MM	man computer smile	man computer	left	Test
man umbrella	MM	umbrella strain2	man umbrella	right	Test
man umbrella strain	INT	umbrella strain2	man umbrella	left	Test
man weight strain	INT	man weight strain2	man weight strain	right	Test
man weight 5	MM	man weight strain2	man weight strain	left	Test
pizza thin	PS	pizza thin	pizza thick	left	Test
shoe small	PS	big shoe	small shoe	right	Test
small money	PS	small pile money	big pile money	left	Test
tap dripping	MM	tap rushing	tap dripping	right	Test
tap rushing	INT	tap dripping	tap rushing	right	Test
woman bag happy	MM	carry happy	bag heavy	left	Test

woman bag struggle	INT	bag heavy	carry happy	left	Test
Waterfall	INT	water	Waterfall	right	Test
woman short skirt	IS	skirt	short skirt	right	Test
woman skirt	NEUTRAL	skirt	short skirt	left	Test
writing big	CHA	writing small	writing big	right	Test
writing small	PS	writing small	writing big	left	Test
sink	NEUTRAL	sink overflow w	sink2	right	Test
sink overflowing	INT	sink2	sink overflow	right	Test

References

- Abusamra, V., Cote, H., Joannette, Y. & Ferreres, A. (2009). Communication impairments in patients with right hemisphere damage. *Life Span and Disability* 12(1): 67-82.
- Adolphs, R., Spezio, M.L., Parlier, M. & Piven, J. (2008). Distinct face processing strategies in parents of autistic children. *Current Biology* 18: 1090-1093.
- Agrafiotis, D., Canagarajah, C.N., Bull, D.R., Kyle, J.G., Twyford, H.E. & Dye, M. (2006). A perceptually optimised video coding system for sign language communication at low bit rates. *Signal processing: Image Communications* 21(7): 531-549
- Anderson, D. & Reilly, J. (1997). The puzzle of negation: How children move from communicative to grammatical negation in ASL. *Journal of Child Language* 18(4): 411-429.
- Anderson, D. & Reilly, J. (1998). Pah! The acquisition of adverbials in ASL. *Sign Language and Linguistics* 1(2): 117-142.
- Anderson, D. & Reilly, J. (2002). The MacArthur Communicative Developmental Inventory: Normative data for American Sign Language. *Journal of Deaf Studies and Deaf Education* 7(2): 83-106.
- Annaz, D., Karmiloff-Smith, A., Johnson, M.H. & Thomas, M. (2009). A cross-syndrome study of the development of holistic face recognition in children with autism, Down syndrome, and Williams syndrome. *Journal of Experimental Child Psychology* 102: 456-486.
- Antzakas, K. (2006). The use of negative head movements in Greek Sign Language. In U. Zeshan (ed.), *Interrogative and negative constructions in sign languages*, Nijmegen: Ishara Press: 258-269.
- Ashwin, C., Chapman, E., Colle, L. & Baron-Cohen, S. (2006). Impaired recognition of negative basic emotions in autism: A test of the amygdala theory. *Social Neuroscience* 1(3-4): 349-363.
- Atkinson, J., Woll, B. & Gathercole, S. (2002). The Impact of Developmental Visuospatial Learning Difficulties on British Sign Language. *Psychology Press* 8: 424-441.
- Atkinson, J., Campbell, R., Marshall, J., Thacker, A. & Woll, B. (2003). Understanding not: Neuropsychological dissociations between hand and head markers of negation in BSL. *Neuropsychologia* 42: 214-229.
- Atwood, A., Frith, U. & Hermelin, B. (1988). The understanding and use of interpersonal gestures by autistic and down syndrome children. *Journal of Autism and Developmental Disorders* 18: 241-257.

Baker, C. & Padden, C.A. (1978). Focusing on the nonmanual components of American Sign Language. *Understanding language through sign language research: perspectives in neurolinguistics and psycholinguistics*. P. Siple. Rochester, Academic Press. Chapter 2: 27-57.

Baker Shenk, C. & Cokely, D. Eds. (1981). *American Sign Language: A teacher's resource text on grammar and culture*. Maryland, Gallaudet University Press. Chapter 6: 121-165.

Baker Shenk, C. (1983). *A microanalysis of the nonmanual components of questions in American Sign Language*. Berkeley, CA, University of California.

Baltaxe, C. A. M. & Guthrie, D. (1987). The use of primary sentence stress by normal, aphasic and autistic children. *Journal of Autism and Developmental Disorders* 17(2): 255-271.

Baranek, G. (1999). Autism during infancy: A retrospective video analysis of sensory-motor and social behaviours at 9-12 months of age. *Journal of Autism and Developmental Disorders* 29: 213-224.

Baron-Cohen, S., Leslie, A.M. & Frith, U. (1985). Does the autistic child have a 'theory of mind'? *Cognition* 21: 37-46.

Baron-Cohen, S. (1992). Out of sight or out of mind? Another look at deception in autism. *Journal of Child Psychol. Psychiat* 33(7): 1141-1155.

Baron-Cohen, S., Spitz, A. & Cross, P. (1993). Do children with autism recognise surprise? A research note. *Cognition and Emotion* 7(6): 506-516.

Baron-Cohen, S., Campbell, R., Karmiloff-Smith, A., Grant, J. & Walker, J. (1995). Are children with autism blind to the mentalistic significance of the eyes? *Journal of Developmental Psychology* 13: 379-398.

Baron-Cohen, S., Cox, A., Baird, G., Swettenham, J., Nightingale, N., Morgan, K., Drew, A. & Charman, T. (1996). Psychological markers in the detection of autism in infancy in a large population. *British Journal of Psychiatry* 168: 158-163.

Bebko, J. M. & McKinnon, E.E. (1993). *The language proficiency profile-2*. unpublished assessment tool. Toronto, Canada, York University. Available from Dr James J. Bebko, Department of Psychology, York University, 4700.

Bebko, J. M. & Goldstein, G. (2008). *Language Proficiency Profile, Social Skills and Stress: Results from Parents of Deaf Children who have Autism Spectrum Disorders. Signing on the spectrum: Meeting the needs of Deaf students with autism*. Boston.

Bellugi, U. & Fischer, S. (1972). A comparison of sign language and spoken language, *Cognition* 1: 173-199.

Bellugi, U., Grady, L., Lillo-Martin, D., Grady, M., Van Hoek, K. & Corina, D. (1990). Enhancement of spatial cognition in deaf children. *From gesture to language in hearing and deaf children*. V. Volterra and C. J. Erting. New York, Springer Verlag: 278-298.

Benton, A. L., Hamsher, K., Varney, N.R. & Spreen, O. (1983). Facial recognition form SL: Stimulus and multiple choice pictures. Iowa City Dept of Neurology, University of Iowa hospitals.

Benton, A. L., Sivan, A.B., Hamsher, K., Varney, N.R. & Spreen, O. (1994). Facial Recognition. *Contributions to Neuropsychological Assessment: A clinical manual*. New York, Oxford University Press.

Bettger, J. G. (1992). The effects of experience on spatial cognition: Deafness and knowledge of ASL, Unpublished dissertation, University of Illinois at Urbana-Champaign.

Bettger, J. G., Emmorey, K., McCullough, S. & Bellugi, U. (1997). Enhanced facial discrimination: effects of experience with American Sign Language. *Journal of Deaf Studies and Deaf Education* 2(4): 223-233.

Bickford, J. A. & Fraychineaud, K. (2008). Mouth morphemes in ASL: A closer look. Sign Languages: Spinning and unravelling the past, present and future, Theoretical issues in sign language research (TISLR9) conference. Florianopolis, Brazil.

Bieberich, A. A. & Morgan, S.B.(1998). Brief Report: Affective Expression in Children with Autism or Down Syndrome. *Journal of Autism and Developmental Disorders* 28(4): 333-338.

Bird, G., Catmur, C., Silani, G., Frith, C. & Frith, U. (2006). Attention does not modulate neural responses to social stimuli in autism spectrum disorders. *Neuroimage* 31: 1614-1624.

Bishop, D. (1998). Development of the Children's Communication Checklist (CCC): A method for assessing qualitative aspects of communicative impairment in children. *Journal of Child Psychology and Psychiatry* 39(6): 879-891.

Blair, R. J. (2003). Facial expressions, their communicatory functions and neuro-cognitive substrates. *The Royal Society* 358: 561-572.

Blennerhassett, I., Strohmeier, S.J. & Hibbett, C. (1994). Criterion related validity of Ravens progressive matrices with deaf residential school students. *American Annals of the Deaf* 139(2): 104-110.

Bogdashina, O. (2003). *Sensory perceptual issues in autism and asperger syndrome: Different sensory experiences, different perceptual worlds*. Gateshead, Athenaeum press: 44-83.

Bonvillian, J.D. & Nelson, K.E. (1976). Sign language acquisition in a mute autistic boy. *Journal of Speech and Hearing Disorders*: 339-347.

Bonvillian, J.D. & Nelson, K.E. (1978). Development of sign language in autistic children and other language handicapped individuals. *Understanding language through sign language research: Perspectives in neurolinguistics and psycholinguistics*. P. Siple, Academic Press: 187-212.

Bonvillian, J. D., Milnes Rhyne, J. & Nelson, K.E. (1981). Sign language and autism. *Journal of Autism and Developmental Disorders* 11(1): 125-137.

Bonvillian, J. D., Thompson-Gershoff, E.T., Seal, B.C. & Richards, H.C. (2001). Hand preferences in sign-learning students with autistic disorder. *Laterality* 6(3): 261-281.

Boucher, J., Lewis, V. & Collins, G. (2000). Voice processing abilities in children with autism, children with specific language impairments and young typically developing children. *Journal of Psychology and Psychiatry and Allied Disciplines* 41(7): 847-857.

Boucher, J. (2003). Language Development in autism. *International Journal of pediatric Otorhinolaryngology* 67s1: s159-s163.

Boudreault, P. & Mayberry, R. (2006). Grammatical processing in American Sign Language: Age of first language acquisition effects in relation to syntactic structure. *Language and Cognitive Processes* 21(5): 608-635.

Bowler, D. M. (1992). "Theory of Mind" in Asperger's syndrome. *The Journal of Child Psychology and Psychiatry* 33(5): 877-893.

Bradley, E. A., Summers, J.A., Wood, H.L. & Bryson, S.E. (2004). Comparing rates of psychiatric and behavioural disorders in adolescents and young adults with severe intellectual disability with and without autism. *Journal of Autism and Developmental Disorders* 34: 151-161.

Bridges, B. & Metzger, M. (1996). *Deaf tend your non manual signals in ASL*. Maryland, Silver Spring, Calliope press.

Brown, C. M. (2007). The role of hearing mother's signing ability in Deaf children's Theory of Mind development. *The New School Psychology Bulletin* 5(1): 59-71.

Brownwell, H. & Martino, G. (1998). Deficits in inference and social cognition: The effects of right hemisphere brain damage on discourse. *Right hemisphere language*

comprehension: Perspectives from cognitive neuroscience. M. Beeman and C. Chiarello. New Jersey, Mahwah, Erlbaum: 309-328.

Bruce, V. (1988). *Recognising faces*. Hillsdale, N.J, Lawrence Erlbaum Associates Inc.

Bruce, R., Campbell, R., Doherty-Sneddon, G., Import, A., Langton, S., McAuley, S. & Wright, R. (2000). Testing face processing skills in children. *British Journal of Developmental Psychology* 18: 319-333.

Bruce, V. & Young, A W (1986). Understanding face recognition. *British Journal of Psychology* 77: 305-327.

Buck, R. (1988). The perception of facial expression: Individual regulation and social coordination. *Social and applied aspects of perceiving faces*. T. Alley, R. Hillsdale NJ, Erlbaum: 141-165.

Campbell, R., Woll, B., Benson, P. & Wallace, S. (1999). Categorical perception of face actions: Their role in sign language and in communicative facial displays. *The quarterly Journal of Experimental Psychology* 52A(1): 67-95.

Capps, L., Yirmiya, N. & Sigman, M. (1992). Understanding of simple and complex emotions in non-retarded children with autism. *Journal of Child Psychol. Psychiat* 13: 1169-1182.

Capps, L., Losh, M. & Thurber, C. (2000). 'The frog ate the bug and made his mouth sad': Narrative competence in children with autism. *Journal of Abnormal Child Psychology* 28: 193-204.

Carpenter, M. (2006). Instrumental, social and shared goals and intentions in imitation. *Imitation and the social mind*. S. J. Rogers and J. H. G. Williams. New York, Guilford: 48-70.

Carr, E. G., Binkoff, J.A., Kologinsky, E. & Eddy, M. (1978). Acquisition of sign language by autistic children, 1- expressive labelling. *Journal of Applied Behaviour Analysis* 2(4): 489-501.

Carr, E. G., Kologinsky, E. & Leff-Simon, S. (1987). Acquisition of sign language by autistic children 3- generalised descriptive phrases. *Journal of Autism and Developmental Disorders* 17(2): 217-229.

Carvill, S. (2001). Sensory impairments, intellectual disability and psychiatry. *Journal of Intellectual Disability Research* 45(6): 467-483.

Castelli, F. (2005). Understanding emotions from standardized facial expressions in autism and normal development. *Autism* 9(4): 428-449.

Cattaneo, L., Fabbri-Destro, M., Boria, S., Pieraccini, C., Monti, A., Cossu, G. & Rizzolatti, G. (2007). Impairment of actions chains in autism and its possible role in intention understanding. *PNAS* 104(45): 17825-17830.

Chaida, A. (2008). Prosodic perception of sentence types in Greek. 2 ISCA Tutorial and Research Workshop on Experimental Linguistics, Athens, Greece.

Chawarska, K., Volkmar, F. & Klin, A. (2010). Limited attentional bias for faces in toddlers with Autism Spectrum Disorders. *Arch. Gen. Psychiatry* 67(2): 178-185.

Chevallier, C., Noveck, I., Happe, F. & Wilson, D. (2009). From acoustics to grammar: Perceiving and interpreting grammatical prosody in adolescents with Asperger Syndrome. *Research in Autism Spectrum Disorders* 3: 502-516.

Cobbold, P. (2000). An investigation into BSL narrative development in deaf children. Unpublished MSc dissertation, City University, London.

Coerts, J. (1992). Non-manual grammatical markers: An analysis of interrogatives, negations and topicalisations in sign language of the Netherlands. Unpublished doctoral dissertation. Amsterdam, University of Amsterdam.

Collins, P. & Carney, S. (2007). Autism spectrum disorder, deafness and challenging behaviour. *Deafness and challenging behaviour, the 360 degree perspective*. S. Austen and D. Jeffrey. West Sussex, John Wiley & Sons: 125-141.

Colville, M. D., Denmark, M., Mason, C., Denmark, C. & Brennan, M. (1984). Edinburgh Non-manual coding system (ENCS) Edinburgh BSL Research Project. Moray House College.

Constantino, J. N. & Gruber, C.P. (2005). Social Responsiveness Scale. Los Angeles, Western Psychological Services.

Conturo, T. E., Williams, D. L., Smith, C.D., Gultepe, E., Akbudak, E. & Minshew, N.J. (2008). Neuronal fiber pathway abnormalities in autism: An initial MRI diffusion tensor tracking study of hippocampo-fusiform and amygdalo-fusiform pathways. *Journal of the International Neuropsychological Society* 14: 933-946.

Corina, D. (1989). Recognition of affective and noncanonical linguistic facial expressions in hearing and deaf subjects. *Brain and Cognition* 9: 227-237.

Corina, D. P., Bellugi, U. & Reilly, J. (1999). Neuropsychological studies of linguistic and affective facial expressions in deaf signers. *Language and Speech* 42(2-3): 307-331.

Cormier, K. & Smith, S. (2010). The role of animacy in the acquisition of entity constructions in British Sign Language. TISLR10, Purdue, Indiana.

Cormier, K., Adam, R., Rowley, K., Atkinson, J. & Woll, B. (2011). British Sign Language Sentence Reproduction Test. Deafness Cognition and Language Research Centre, University College London.

Costello, B., Fernandez, F. & Landa, A. (2006). The non-(existent) native signer: sign language research in a small deaf population. TISLR9, Florianopolis, Brazil.

Courtin, C. (2000). The impact of sign language on the cognitive development of deaf children: The case of theories of mind. *Journal of Deaf Studies and Deaf Education* 5(3): 266-276.

Dalton, K., Nacewicz, B., Johnstone, T., Schaefer, H., Gernsbacher, M.A., Goldsmith, H., Alexander, A. & Davidson, R.J. (2005). Gaze fixation and the neural circuitry of face processing in autism. *Nature Neuroscience* 8 (4): 519-526.

Dapretto, M., Davies, M.S., Pfeifer, J.H., Scott, A.A., Sigman, M., Bookheimer, S.Y et al., (2006). Understanding emotions in others: Mirror neuron dysfunction in children with autism spectrum disorders. *Nature Neuroscience* 9: 28-30.

Dara, C. & Pell, M.D. (2006). Effects of right-hemisphere damage on explicit and implicit processing of emotional prosody. *Brain and Language* 99(1-2): 41-42.

Dawson, G., Toth, K., Abbot, R., Osterling, J., Munson, J., Estes, A. & Liaw, J. (2004). Early social attention impairments in autism: Social orienting, joint attention and attention to distress. *Developmental Psychology* 40(2): 271-283.

Dawson, G., Webb, S.J. & McPartland, J. (2005). Understanding the nature of face processing impairment in autism; Insights from behavioural and electrophysiological studies. *Developmental Neuropsychology* 27(3): 403-424.

Dawson, M., Soulières, I., Gernsbacher, M.A. & Mottron, L. (2007). The level and nature of autistic intelligence. *Psychological Science* 18: 657-662.

De Gelder, B., Vroomen, J. & Van der Heide, L. (1991). Face recognition and lip-reading in Autism. *European Journal of Social Psychology* 3(1): 69-86.

De Lima Velloso, R., De Aroulo, C.A. & Schwartzman, J.S. (2009) Concepts of color, shape, size and position in ten children with RETT syndrome. *Arq. Neuropsiquiatr.* 67(1):50-54.

De Marchena, A. & Eigsti, I. (2010). Conversational gestures in autism spectrum disorders: Asynchrony but not decreased frequency. *Autism Research* 3(6): 311-322.

Denmark, J. C. (1990). Psychological, sociological and cultural aspects of deafness. *Deafness and mental health*. J. C. Denmark. Pennsylvania Jessica Kingsley publishers. Chapter 1: 4-25.

Denmark, T., Swettenham, J. & Atkinson, J. (2007). Do deaf children have superior face processing? Unpublished MRes dissertation. UCL, London.

Dennis, M., Lockyer, L. & Lazenby, A. (2000). How high functioning children with autism understand real and deceptive emotion. *Autism* 4: 370.

De Renzi, E. & Vignolo, I.A. (1962). The token test: A sensitive test to detect receptive disturbances in aphasics. *Brain* 35: 665-678.

De Vos, C., Van der Kooij, E. & Crasbourn, O. (2009). Mixed signals: Combining linguistic and affective functions of eyebrows in questions in Sign Language of the Netherlands. *Language and Speech* 52(2-3): 315-339.

Diagnostic and Statistical Manual of Mental Disorders (DSM-IV) Washington DC, APA.

Dinstein, I., Thomas, C., Behrmann, M. & Heeger, D.J. (2008). A mirror up to nature, *Current Biology* 8, 18: R13-18.

Duchaine, B. C. & Nakayama, K. (2004). Developmental prosopagnosia and the Benton facial recognition test. *Neurology* 62: 1219-1220.

Dutta, T. & Mandal, M.K. (2002). Visual-field superiority as a function of stimulus type and content. *International Journal of Neuroscience* 112: 945-952.

Edwards, L. & Crocker, S. (2008). *Psychological processes in deaf children with complex needs: An evidence based practical guide*. London, Jessica Kingsley Publishers: 106-131.

Ekman, P. & Friesen, W.V. (1976). Pictures of facial affect, Consulting Psychologists.

Ekman, P. & Friesen, W.V. (1978). *Facial Action Coding System: A technique for the measurement of facial movement*, Consulting Psychologists.

Ekman, P. (1993). Facial expression and emotion. *American Psychologist* 48(4): 376-379.

Ekman, P., Friesen, W.V. & Hager, J.C. (2002). *The facial action coding system* (2nd ed.). Salt Lake City, UT, Research Nexus eBook.

Ekman, P. (2003). *Emotions revealed*. New York, Owl books: 84-172.

Ellis-Gonzales, S. (2008). *Selah, a Previous Mosaic: A Mother's Journey Through Autism with Her Deaf Child*. Odyssey Magazine, Gallaudet University, Washington DC.

- Emmorey, K. (1998). Sign language and visuospatial cognition. *Psychological perspectives on deafness*. M. Marshark and M. D. Clark. Mahwah, New Jersey, Lawrence Erlbaum Associates: 19-52.
- Emmorey, K. (2002). Sign Language and the Brain. *Language, Cognition and the Brain: Insights from sign language research*, Lawrence Erlbaum Associates: 271-314.
- Emmorey, K. (2002). The critical period hypothesis and the effect of late language acquisition. *Language, cognition and the brain: Insights from sign language research*. K. Emmorey. Mahwah NJ, Lawrence Erlbaum Associates: 205-225.
- Emmorey, K. & McCullough, S. (2008). The bimodal bilingual brain: Effects of sign language experience. *Brain and Language* 110 (2): 208-221.
- Emmorey, K., Borinstein, H.B., Thompson, R. & Gollan, T.H. (2008). Bimodal bilingualism. *Bilingualism: Language and Cognition* 11(1): 43-61.
- Emmorey, K., Gigi, L., Pyers, J. & Bialystok, E. (2008). The source of enhanced cognitive control in bilinguals: evidence from bimodal bilinguals. *Psychological Science* 19(12): 1201-6.
- Farroni, T., Massaccesi, S., Menon, E. & Johnson, M.H. (2007). Direct gaze modulates face recognition in young infants. *Cognition* 102(3): 396-404.
- Fenson, L., Dale, P.S., Resnick, S.J., Thal, D., Bates, E., Hartung, J.P., Pethick, S. & Reilly, J. (1993). *The MacArthur Communicative Developmental Inventories: User's guide and technical manual*. San Diego, Singular Publishing Group.
- Figueras, B. & Harris, P. (2001). Theory of Mind development in deaf children: A nonverbal test of false belief understanding. *Journal of Deaf Studies and Deaf Education* 6(2): 92-102.
- Fodor, J.A. (1968) *Psychological Explanation: An introduction to the philosophy of psychology*, New York: Random House: 25-40.
- Fombonne, E. (2005). Epidemiology of autistic disorder and other pervasive developmental disorders. *J. Clin. Psychiatry* 66(supp 10): 3-8.
- Fontana, S. (2008). Mouth actions as gesture in sign language. *Gesture* 8(1): 104-123.
- Fosnot, S. & Jun, S (1999). Prosodic characteristics in children with stuttering or autism during reading and imitation. *ICPS*.
- Frank, M. C., Vul, E. & Johnson, S.P. (2009). Development of infants' attention to faces during the first year. *Cognition* 110: 160-170.
- Frith, U. (1989). *Autism: explaining the enigma*. Oxford, Blackwell: 1-16.

- Frith, U. (2001). Mind blindness review and the brain in autism. *Neuron* 32: 969-979.
- Fulwiler, R. L. & Fouts, R.S. (1976). Acquisition of ASL by a non communicating autistic child. *Journal of Autism and Childhood Schizophrenia* 6(1): 43-51.
- Gillberg, C., Ehlers, S., Schaumann, H., Jakobsson, G., Dahlgren, S.O., Lindblom, R., Bagenholm, A., Tjuus, T. & Blidner, E. (1990). Autism under age 3 years: a clinical study of 28 cases referred for autistic symptoms in infancy. *Journal of Child Psychology and Psychiatry* 31: 921-34.
- Golan, O., Ashwin, E., Granader, Y., McClintock, S., Day, K., Leggett, V. Baron Cohen, S. (2009). Enhancing emotion recognition in children with autism spectrum conditions: An intervention using animated vehicles with real emotional faces. *Journal of Autism and Developmental Disorders* 40 (3): 269-279
- Goldstein, N. E., Sexton, J. & Feldman, R.S. (2000). Encoding of facial expressions of emotion and knowledge of American Sign Language. *Journal of Applied Social Psychology* 30(1): 67-76.
- Goodwin, A., Fein, D. & Naigles, L. (2009). Production of Wh-Questions in young children with autism. IMFAR, Chicago.
- Gosselin, F. & Schyns, P.G. (2001). Bubbles: a technique to reveal the use of information in recognition tasks. *Vision Research* 41: 2261-2271.
- Grelotti, D. J., Gauthier, I. & Schultz, R.T. (2002). Social interest and the development of cortical face specialisation: What autism teaches us about face processing. *Developmental Psychobiology* 40(3): 213-225.
- Grossman, R. B. & Kegl, J. (2007). Moving faces: Categorisation of dynamic facial expressions in American Sign Language by deaf and hearing participants. *Journal of Nonverbal Behaviour* 31: 23-38.
- Grossman, R. B. & Tager Flusberg, H. (2008). Reading faces for information about words and emotions in adolescents with autism. *Research in Autism Spectrum Disorders* 2 (4): 681-695.
- Hamilton, A. F., Brindley, R.M. & Frith, U. (2007). Imitation and action understanding in autism spectrum disorders: How valid is the hypothesis of a deficit in the mirror neuron system? *Neuropsychologia* 45: 1859-1868.
- Hao, J., Su, Y. & Chan, R.C.K. (2010). Do deaf adults with limited language have advanced theory of mind? *Research in Developmental Disabilities* 31: 1491-1501.

- Happe, F. (1995). The role of age and verbal ability in the theory of mind task performance of subjects with autism. *Child Development* 66: 843-855.
- Harley, T., Ed. (2001). *The psychology of language: from data to theory*, Taylor and Francis: 19-24.
- Harris, M. (2000). Social interaction and early language development in deaf children. *Deafness and Education International* 2 (2): 1-11.
- Hauser, P. C., Paludneviciene, R., Supalla, T. & Bavelier, D. (2006). *American Sign Language-Sentence Reproduction Test: Development and Implications*. Theoretical issues in sign language research conference, Florianopolis, Brazil.
- Heerey, E. A., Keltner, D. & Capps, L. (2003). Making sense of self conscious emotion: linking theory of mind and emotion in children with autism. *Emotion* 3(4): 394-400.
- Hendricks, B. (2007b). Negation in Jordanian Sign Language: A cross-linguistic perspective. *Visible variation: Cross-linguistic studies in sign language structure*. P. Perniss, R. Pfau and M. Steinbach. Berlin, Mouton de Gruyter: 103-128.
- Herba, C. M., Landau, S., Russell, T., Ecker, C. & Phillips, M.L. (2006). The development of emotion-processing in children: Effects of age, emotion and intensity. *Journal of Child Psychol. Psychiat* 47: 1098-1106.
- Herman, R., Holmes, S. & Woll, B. (1999). BSL test of receptive abilities in deaf children. Assessing BSL development- receptive skills test. Coleford UK, The forest Bookshop.
- Herman, R., Grove, N., Holmes, S., Morgan, G., Sutherland, H. & Woll, B. (2004). BSL test of narrative abilities in deaf children. Assessing BSL development- Production test. Coleford UK, The forest Bookshop.
- Hickock, G., Klima, E., Kritchevsky, M. & Bellugi, U. (1995). A case of "sign blindness" following left occipital damage in a deaf signer. *Neuropsychologia* 33: 1597-1606.
- Hickok, G., Love-Geffen, T. & Klima, E. (2002). Role of the left hemisphere in sign language comprehension. *Brain and Language* 82: 167-178.
- Hietanen, J., K. & Leppänen, J.M. (2008). Judgment of other people's facial expressions of emotions is influenced by their concurrent affective hand movements. *Scandinavian Journal of Psychology* 49: 221-230.
- Hill, E. L. & Frith, U. (2003). Understanding autism: Insights from mind and brain. *Phil. Trans. R. Soc. Lond. B* 358: 281-289.
- Hindley, P. (2000). Child and adolescent psychiatry. *Mental health and deafness*. P. Hindley and N. Kitson. London, Whurr: 75-99.

- Hindley, P. A. (2005). Mental health problems in deaf children. *Current Paediatrics* 15: 114-119.
- Hintermair, M. (2007). Prevalence of socioemotional problems in deaf and hard of hearing children in Germany. *American Annals of the Deaf* 152 (3): 320-330.
- Hobson, R. P. (1984). Early childhood autism and the question of egocentrism. *Journal of Autism and Developmental Disorders* 14: 85-104.
- Hobson, R.P. & Lee, A. (1989). Emotion-related and abstract concepts in autistic people: Evidence from the British Picture Vocabulary Scale. *Journal of Autism and Developmental Disorders*. 19(4):601-623.
- Hobson, R.P. (1991). Methodological issues for experiments on autistic individuals' perception and understanding of emotion. *Journal of Child Psychology and Psychiatry* 32(7):1135-1158.
- Hobson, R.P. (1995). *Autism and the Development of Mind*. Hillsdale, N.J.: Lawrence Erlbaum Associates Ltd: 53-100.
- Hobson, R.P. & Lee, A. (1999). Imitation and identification in autism. *Journal of Child Psychology and Psychiatry* 40(4): 649-549.
- Hobson, R.P. & Meyer, J.A. (2005). Foundations for self and other: A study in autism. *Developmental Science* 8(6): 481-491.
- Hobson, R.P., Lee, A & Hobson, J.A. (2007). Only connect? Communication, identification and autism. *Social Neuroscience* 2: 320-335.
- Hobson, J. A. & Hobson, R.P. (2007). Identification: The missing link between joint attention and imitation? *Development and Psychopathology* 19: 411-431.
- Hobson, R.P. & Hobson, J.A. (2008). Dissociable aspects of imitation: A study in autism. *Journal of Experimental Child Psychology* 101: 170-185.
- Hosie, J. A., Gray, C.D., Russell, P.A., Scott, C. & Hunter, N. (1998). The matching of facial expressions by deaf and hearing children and their production and comprehension of emotion labels. *Motivation and Emotion* 22(4): 293-313.
- Howard, M. A., Cowell, P.E., Boucher, J., Brooks, P., Mayes, A., Farrant, A. & Roberts, N. (2000). Convergent neuroanatomical and behavioural evidence of an amygdala hypothesis of autism. *Neuroreport* 11(13): 2931-2935.

- Hughes, C. & Leekam, S. (2004). What are the links between theory of mind and social relations? Review, reflections and new directions for studies of typical and atypical development. *Social Development* 13(4):590-619.
- Hulme, C. & Snowling, M.J. Eds. (2009). *Developmental disorders of language learning and cognition*. West Sussex, John Wiley & Sons Ltd: 284-327.
- Hurtig, R., Ensrud, S. & Tomblin, B. (1982). The communicative function of question production in autistic children. *Journal of Autism and Developmental Disorders* 12(1): 57-69.
- Ingersoll, B. (2008). The effect of context on imitation skills in children with autism. *Research in Autism Spectrum Disorders* 2(2): 332-340.
- Ingersoll, B. (2008). The social role of imitation in autism, implications for the treatment of imitation deficits. *Infants and Young Children* 21(2): 107-119.
- Jeffrey, D. & Austen, S. (2007). De escalation and deafness: seeing the signs. *Deafness and Challenging behaviour: The 360 degree perspective*. S. Austen and D. Jeffrey. West Sussex, John Wiley and sons: 159-176.
- Jemel, B., Mottron, S. & Dawson, M. (2006). Impaired face processing in autism: fact or artifact. *Journal of Autism and Developmental Disorders* 36(1): 91-106.
- Johnson, M. H., Dziurawiec, S., Ellis, H.D. & Morton, J. (1991). Newborns preferential tracking of face-like stimuli and its subsequent decline. *Cognition* 40: 1-19.
- Joseph, R. M. & Tanaka, J. (2002). Holistic and part based face recognition in children with autism. *Journal of Child Psychology and Psychiatry* 44(4): 529-542.
- Jure, R., Rapin, I. & Tuchman, R.F. (1991). Hearing impaired autistic children *Developmental Medicine and Child Neurology* 33: 1062-1072.
- Kasari, C., Sigman, M., Mundy, P. & Yirmiya, N. (1990). Affective sharing in the context of joint attention interactions of normal, autistic and mentally retarded children. *Journal of Autism and Developmental Disorders* 20(1): 87-100.
- Kaufman, A. S. & Kaufman, N.L. (1983). *K-ABC: Kaufman Assessment battery for children, Interpretative manual*. Circle Pines, MN, American Guidance Service.
- Kegl, J. & Poizner, H. (1996). Crosslinguistic/crossmodal syntactic consequence of left hemisphere damage: Evidence from an aphasic signer and his identical twin. *Aphasiology* 11: 1-37.

- Klin, A., Sparrow, S.S., De Bildt, A., Cichetti, D.V., Cohen, D.J & Volkmar, F.R. (1999). A normed study of face recognition in autism and related disorders. *Journal of Autism and Developmental Disorders* 29(6): 499-508.
- Klin, A., Jones, W., Schultz, R., Volkmar, F. & Cohen, D. (2002). Visual fixation patterns during viewing of naturalistic social situations as predictors of social competence in individuals with autism. *Archives of General Psychiatry* 59(9): 809-816.
- Klin, A., Jones, W., Schultz, R. & Volkmar, F. (2003). The enactive mind; From actions to cognition. *Phil. Trans. R. Soc. London. B. Biol. Sci.* 28, 358(1430): 345-360.
- Klin, A., McPartland, J. & Volkmar, F. (2005). Asperger syndrome. *Handbook of autism and pervasive developmental disorders*. F. Volkmar, R. Paul, A. Klin and D. Cohen. New Jersey, John Wiley and sons. 3: 88-125.
- Klin, A. (2006). Autism and Asperger syndrome: an overview. *Revista Brasileira de Psiquiatria* 28(1): 3-11.
- Kolod, E. (2004). How does learning sign language affect perception? *Intel Science Talent Search*: 1-20.
- Kogan, M. D., Blumberg, S.J., Schieve, L.A., Boyle., C.A., Perrin., J.M., Ghandour, R.M., Singh, G.K., Strickland, B.P., Trevathen, E. & Van Dyck, P.C. (2009). Prevalence of parent-reported diagnosis of autism spectrum disorder among children in the US, 2007. *Pediatrics* 124 (5):1395-403.
- Konstantareas, M., Oxman, J. & Webster, C.D. (1978). Iconicity; Effects on the acquisition of sign language by autistic and other severely dysfunctional children. *Understanding language through sign language research: Perspectives in neurolinguistics and psycholinguistics*. P. Siple, Academic Press: 213-237.
- Koshino, H., Kana, R.K., Keller, T.A., Cherkassy, I., Minshew, N.J. & Adam Just, M. (2007). fMRI investigation of working memory for faces in autism: visual coding and underconnectivity with frontal areas. *Cerebral Cortex*.18: 289-300.
- Lacroix, A., Guidetti, M., Roge, B. & Reilly, J. (2009). Recognition of emotional and nonemotional facial expressions: A comparison between Williams syndrome and autism. *Research in Developmental Disorders* 30: 976-985.
- Lahaie, A., Mottron, L., Arguin, M., Berthiaume, C., Jemel, B. & Saumier, D. (2006). Face perception in high-functioning autistic adults: evidence for superior processing of face parts, not for a configural face-processing deficit. *Neuropsychology* 20(1): 30-41.
- Landa, R. (2000). Social language use in Asperger syndrome and high functioning autism. *Asperger syndrome*. A. Klin, F. Volkmar and S. S. Sparrow. New York, Guilford: 125-155.

- Lavie, N., Ro, T. & Russell, C. (2003). The role of perceptual load in processing distractor faces. *Psychological Science* 14: 510-515.
- Law Smith, M. J., Montagne, B., Perrett, D., Gill, M. & Gallagher, L. (2010). Detecting subtle facial emotion recognition deficits in high functioning autism using dynamic stimuli of varying intensities. *Neuropsychologia* 48(9): 2777-2781.
- Le Grand, R., Mondloch, C.J., Maurer, D. & Brent, H.P. (2001). Impairment in holistic face processing following early visual deprivation. *Psychological Science* 15(11): 762-768.
- Le Grand, R., Mondloch, C.J., Maurer, D. & Brent, H.P. (2003). Expert face processing requires visual input to the right hemisphere during infancy. *Nature Neuroscience* 6: 1108-1112.
- Leslie, A.M. & Frith, U. (1987). Metarepresentation and autism: How not to lose one's marbles. *Cognition* 29: 291-294.
- Leslie, A. M. & Happe, F. (1989). Autism and ostensive communication: The relevance of metarepresentation. *Development and Psychopathology* 1: 205-12.
- Lewin, D. & Schembri, A. (2009). Adverbial mouth gestures in British Sign Language: A case study of tongue protrusion in BSL narratives. Workshop on Nonmanuals in Sign Languages. Frankfurt.
- Lewin, D. & Schembri, A. (in press). Mouth gestures in British Sign Language: A case study of tongue protrusion in BSL narratives. *Sign Language & Linguistics*.
- Liddell, S. (1980). *American Sign Language Syntax*. Paris, New York, The Hague: 7-65.
- Lillo-Martin, D. (2000). Early and late in language acquisition: Aspects of the syntax and acquisition of Wh questions in ASL. Anthology to honor Bellugi and Klima: *The signs of language revisited*. Emmorey, K. & Lane, H: 400-401.
- Loew, R. C., Kegl, J. & Poizner, H. (1997). Fractionation of the components of role play in a right hemispheric lesioned signer. *Aphasiology* 11(3): 263-281.
- Lord, C., Rutter, M., Lambrecht, L., Cook, E.H., Leventhal, B.L., DiLavore, P.S., Pickles, A. & Risi, S. (2000). The Autism Diagnostic Observation Schedule- Generic: A standard measure of social and communication deficits associated with the spectrum of autism. *Journal of Autism and Developmental Disorders* 30: 205-223.
- Losh, M. & Capps, L. (2003). Narrative ability in high functioning children with autism or aspergers syndrome. *Journal of Autism and Developmental Disorders* 33(3): 239-251.

- Loveland, K. A., Landry, S.H., Hughes, S.O., Hall, S.K. & McEvoy, R.E. (1988). Speech acts and the pragmatic deficits of autism. *Journal of Speech and Hearing Research* 31(4): 593-604.
- Loveland, K. A., Tunali-Kotoski, B., Pearson, D.A., Brelsford, K.A., Ortegon, J. & Chen, R. (1994). Imitation and expression of facial affect in autism. *Development and Psychopathology* 6: 433-444.
- Loveland, K. A., Tunali-Kotoski, B., Chen, R., Ortegon, J., Pearson, D.A., Brelsford K.A. & Cullen Gibbs, M. (1997). Emotion recognition in autism: verbal and nonverbal information. *Development and Psychopathology* 9: 579-593.
- MacLaren, R. & Olson, D. (1993). Trick or treat: Children's understanding of surprise. *Cognitive Development* 8(1): 27-46.
- MacDonald, H., Rutter, M., Howlin, P., Rios, P., Le Couteur, A., Evered, C. & Folstein, S. (1989). Recognition and expression of emotional cues by autistic and normal adults. *Journal of Child Psychol. Psychiat.* 30(6): 865-877.
- Malandraki, G. A. & Okalidou, A. (2007). The application of PECS in a deaf child with autism: A case study. *Focus on Autism and other Developmental Disabilities* 22(1): 23-32.
- Mann, W. (2009). British Sign Language Vocabulary Test (BSL-VT) London, City University.
- Markham, R. & Adams, K. (1992). The effect of type of task on children's identification of facial expressions. *Journal of Nonverbal Behaviour* 16: 21-39.
- Marschark, M., Green, V., Hindmarsh, G. & Walker, S. (2000). Understanding theory of mind in children who are deaf. *Journal of Child Psycho. Psychiat.* 41(8):1067-1073.
- Mason, K., Rowley, K., Marshall, C., Atkinson, J., Herman, R., Woll, B & Morgan, G. (2009). Identifying specific language impairment in deaf children acquiring British Sign Language: Implications for theory and practice. *British Journal of Developmental Psychology*.
- Mayberry, R. I., Fischer, S.F. & Hatfield, N. (1983). Sentence Repetition in American Sign Language. *Language in sign: An international perspective on sign language*. J. Kyle and B. Woll. London, Croom Helm: 206-215.
- Mayberry, R. I. & Eichen, E.B. (1991). The long lasting advantage of learning sign language in childhood: Another look at the critical period for language acquisition, *Journal of Memory and Language* 30: 486-512

- Mayberry, R. & Lock, E. (2003). Age constraints on first versus second language acquisition: Evidence for linguistic plasticity and epigenesis. *Brain and Language* 87: 369-384
- Mayberry, R. & Squires, B. (2006). Sign Language acquisition: Language acquisition. *Encyclopedia of language and linguistics 2nd ed.* Brown, K (Ed.). E. Lieven. Oxford, Elsevier. 11: 291-296.
- Mazefsky, C. A. & Oswald, D.P. (2007). Emotion perception in asperger's syndrome and high functioning autism: The importance of diagnostic criteria and cue intensity. *Journal of Autism and Developmental Disorders* 37: 1086-1095.
- McCabe, A. & Peterson, C. (1990). What makes a narrative memorable? *Applied Psycholinguistics* 11: 73-82.
- McCann, J. & Peppe, S. (2003). Prosody in autism spectrum disorders: A critical review. *International Journal of Language and Communication Disorders* 38(4): 325-350.
- McCullough, S. & Emmorey, K. (2009). Categorical perception of affective and linguistic facial expressions. *Cognition* 110(2): 208-221.
- McCullough, S., Emmorey, K. & Sereno, M. (2005). Neural organisation for recognition of grammatical and emotional facial expressions in deaf ASL signers and hearing non signers. *Cognitive Brain Research* 22: 193-203.
- McCullough, S. & Emmorey, K. (1997). Face processing by deaf ASL signers; Evidence for expertise in distinguishing local features. *Journal of Deaf Studies and Deaf Education* 2(4): 212-221.
- McIntire, M. & Reilly, J (1988). Non manual behaviours in L1 & L2 learners of American Sign Language. *Sign Language Studies* 61: 352-376.
- McIntosh, D. E., Reichmann-Decker, A., Winkielman, P. & Wilbarger, J.L. (2006). When the social mirror breaks: Deficits in automatic, but not voluntary mimicry of emotional facial expressions in autism. *Developmental Science* 9(3): 295-302.
- McPhee, J.T. & Shapiro, E.G. (1993). Revised manual for the Minnesota preschool affect rating scales. University of Minnesota, Minneapolis, Division of Pediatric Neurology.
- Meier, R. (2002). Why different, why the same? Explaining effects and non-effects of modality upon linguistic structure in sign and speech. *Modality and structure in spoken and signed languages*. R. Meier, P. K. Cormier and D. Quinto-Pozos. Cambridge, Cambridge University Press: 1-26.
- Meir, I. & Sandler, W. (2004). *Language in space: A window on Israeli sign language*. Haifa, University of Haifa press.

Meir, I. (2004). Questions and negation in Israeli sign language. *Sign Language and Linguistics* 7(2): 97-124.

Messing, L. S. & Campbell, R. (1999). *Gesture, speech and sign*, Oxford university press.

Mier, D., Lis, S., Neuthe, K., Sauer, C., Esslinger, C., Gallhoffer, B et al., (2010). The involvement of emotion recognition in affective theory of mind *Psychophysiology*. 47(6):1028-1039.

Mondloch, C. J., Le Grand, R. & Maurer, D. (2002). Configural face processing develops more slowly than featural face processing. *Perception* 31: 553-566.

Mondloch, C. J., Geldart, S., Maurer, D. & Le Grand, R. (2003). Developmental changes in face processing skills. *Journal of Experimental Child Psychology* 86: 67-84.

Montagne, B., Kessels, R.P., De Haan, E.H. & Perrett, D. (2007). The emotion recognition task: A paradigm to measure the perception of facial emotional expressions at different intensities. *Perceptual and Motor Skills* 104: 589-598.

Morgan, G., Smith, N., Tsimpli, I. & Woll, B. (2002). Language against the odds: the learning of British Sign Language by a polyglot savant. *Journal of Linguistics* 38: 1-41.

Morgan, G. & Kegl, J. (2006). Nicaraguan sign language and theory of mind: The issue of critical periods and abilities. *Journal of Child Psychol. Psychiat* 47: 811-819.

Morgan, G., Herman, R. & Woll, B. (2007). Language impairments in sign language; breakthroughs and puzzles. *International Journal of Language and Communication Disorders* 42(1): 97-105.

Morgan, G. & Woll, B. (2007). Understanding sign language classifiers through a polycomponential approach. *Lingua* 117: 1159-1168.

Morgan, G. (2010). Infant theory of mind development: The early importance of access to conversation. Goldsmiths University Psychology seminar series. London

Muller, E. & Schuler, A. (2006). Verbal marking of affect by children with asperger syndrome and high functioning autism during spontaneous interactions with family members. *Journal of Autism and Developmental Disorders* 36: 1089-1100.

Mundy, P., Sigman, M. & Kasari, C. (1990). A longitudinal study of joint attention and language development in autistic children. *Journal of Autism and Developmental Disorders* 20(1): 115-128.

Mundy, P. & Neal, R. (2000). Neural Plasticity, joint attention and a transactional social-orienting model of autism. *International review of research in mental retardation*. L. Glidden. New York, Academic Press: 19-20.

Mundy, P., Delgado, C.E., Block, J, Venezia, M., Hogan A. & Seibert, J. (2003). A manual for the abridged Early Social Communication Scales (ESCS). University of Miami Psychology Department, Coral Gables, Florida.

Musselman, C., Mackay, S., Trehub, S.C. & Eagle, R.S. (1996). Communicative competence and psychosocial development in deaf children and adolescents. *Language learning and behaviour disorders: Developmental, biological and clinical perspectives*. J. H. Beitchman, M. M. Cohen, M. Konstantareas and R. Tannock. Cambridge, Cambridge University Press: 555-570.

Naigles, L., Jaffery, G., Tek, S. & Fein, D. (2008). Grammatical strengths in the language of young children with autism. IMFAR, London.

Neidle, C., Kegl, J., MacLaughlin, D., Bahan, B. & Lee, R.G. (2000). Language in the visual modality. *The syntax of American Sign Language*. Cambridge, Massachusetts, MIT Press: 38-48.

Nelson, C. A. (2001). The development and neural bases of face recognition. *Infant and Child Development* 10: 3-18.

Newman, A. J., Bavelier, D., Corina, D., Jezzard, P. & Neville, H.J. (2001). A critical period for right hemisphere recruitment in American Sign Language processing. *Nature Neuroscience* 5(1): 76-80.

Nielsen, M., Simcock, G. & Jenkins, L. (2008). The effect of social engagement on 24-month-olds' imitation from live and televised models. *Developmental Science* 11(5): 722-731.

Oberman, L.M., Hubbard, M., McCleary, J.P., Altschuler, E.L., Ramachandran, V.S. & Pineda, J.A. (2005). EEG evidence for mirror neuron dysfunction in autism spectrum disorder, *Brain Research Cognitive Brain Research*, 24; 190-198

Oberman, L. M. & Ramachandran, V.S. (2007). The simulating social mind: The role of the mirror neuron system and simulation in the social and communicative deficits of autism spectrum disorders. *Psychological Bulletin* 133(2): 310-327.

Osterling, J. & Dawson, G. (1994). Early recognition of children with autism: A study of first birthday home videotapes. *Journal of Autism and Developmental Disorders* 24: 247-257.

Palermo, R. & Rhodes, G. (2006). Are you always on my mind? A review of how face perception and attention interact. *Neuropsychologia* 45 (1):75-92.

- Parasnis, I., Samar, V.J., Bettger, J.G. & Sathe, K. (1996). Does deafness lead to enhancement of visual spatial cognition in children? Negative evidence from deaf non signers. *Journal of Deaf Studies and Deaf Education* 1(2): 145-152.
- Pascalis, O., De Haan, M. & Nelson, C.A. (2002). Is face processing species-specific during the first year of life? *Science* 296: 1321-1323.
- Paul, P. V. (1998). *Literacy and deafness: The development of reading, writing and literate thought*. Needham, MA, Allyn & Bacon: 15-29.
- Paul, R., Orlovski, S.M., Marcinko, H.C. & Volkmar, F. (2009). Conversational behaviours in youth with high functioning ASD and asperger syndrome. *Journal of Autism and Developmental Disorders* 39: 115-125.
- Pellicano, E., Jeffrey, L., Burr, D. & Rhodes, G. (2007). Abnormal adaptive face-coding mechanisms in children with autism spectrum disorder. *Current Biology* 17: 1508-1512.
- Pelphrey, K. A., Sasson, N.J., Reznick, S.J., Paul, G., Goldman., B.D. & Piven, J. (2002). Visual scanning of faces in autism. *Journal of Autism and Developmental Disorders* 32(4): 249-261.
- Penn, C., Commerford, A. & Ogilvy, D. (2007). Spatial and facial processing in the signed discourse of two groups of deaf signers with clinical language impairment. *Clinical Linguistics and Phonetics* 21(5): 369-391.
- Peppe, S., McCann, J., Gibbon, F.O., Hare, A. & Rutherford, M. (2006). Assessing prosodic and pragmatic ability in children with high functioning autism. *Journal of Pragmatics* 38: 1776-1791.
- Peppe, S., McCann, J., Gibbon, F. O., Hare, A. & Rutherford, M. (2007). Receptive and expressive prosodic ability in children with high functioning autism. *Journal of Speech Language and Hearing Research* 50: 1015-1028.
- Perner, J., Leekam, S. & Wimmer, H.M. (1987). Three year olds' difficulty with false belief: The case for a conceptual deficit. *The British Journal of Developmental Psychology* 5: 125-137.
- Peterson, C. C. & Siegal, M. (1999). Representing inner worlds: Theory of mind in autistic, deaf and normal hearing children. *Psychological Science* 10: 126-129.
- Peterson, C. C. & Siegal, M. (2000). Insights into theory of mind from deafness and autism. *Mind and Language* 15(1): 123-145.
- Peterson, C. C., Wellman, H.M. & Liu, D. (2005). Steps in theory of mind development for children with deafness or autism. *Child Development* 76(2): 502-517.

- Peterson, C. C. & Wellman, H.M. (2009). From fancy to reason: Scaling deaf and hearing children's understanding of theory of mind and pretence. *British Journal of Developmental Psychology* 27(2): 297-310.
- Petronio, K. & Dively, V.L. (2006). "YES, # NO, visibility and variation in ASL and tactile ASL." *Sign Language Studies* 7(1): 57-98.
- Pfau, R. & Quer, J. (2004). On the syntax of negation and modals in LSC and DGS. Jahrestagung der Deutschen Gesellschaft für Sprachwissenschaft 26th Annual Meeting of the German Linguistic Society (DGfS), Mainz.
- Pfau, R. & Quer, J. (2010), Nonmanuals: their prosodic and grammatical roles. In: Brentari, Diane (ed.), *Sign languages (Cambridge Language Surveys)*. Cambridge: Cambridge University Press, 381-402
- Philip, R. C. M., Whalley, H.C., Stanfield, A.C., Sprengelmeyer, R., Santos, I.M., Young, A.W., Atkinson, A.P., Calder, A.J., Johnstone, E.C., Lawrie, S.M. & Hall, J. (2010). Deficits in facial, body movement and vocal emotional processing in autism spectrum disorders. *Psychological Medicine*: 1-11.
- Phillips, W., Baron-Cohen, S. & Rutter, M. (1992). The role of eye contact in goal detection: Evidence from normal infants and children with autism or mental handicap. *Development and Psychopathology* 4: 375-383.
- Plaisted, K. & Davis, G. (2009). Perception and apperception in autism: rejecting the inverse assumption. *Phil. Trans. R. Soc. Lond. B* 364(1522): 1393-1398.
- Poizner, H., Klima, E.S. & Bellugi, U. (1990). Signers with strokes: Left hemisphere lesions. *What the hands reveal about the brain*. H. Poizner, E. S. Klima and U. Bellugi. London, MIT press: 133-150.
- Poulsen, D., Kintsch, E. & Kintsch, W. (1979). Children's comprehension and memory for stories. *Journal of Experimental Child Psychology* 28: 379-403.
- Press, C., Richardson, D.C. & Bird, G. (2010). Intact imitation of emotional facial expressions in autism spectrum conditions. *Neuropsychologia*, 48(11), 3291-3297.
- Prior, M. (2003). Is there an increase in the prevalence of autism spectrum disorders? *Journal of Pediatrics and Child Health* 39: 81-82.
- Raymaekers, R., Wiersma, J.R. & Roeyers, H. (2009). EEG study of the mirror neuron system in children with high functioning autism, *Brain Research*, 22 (1304):113-21.
- Raven, J., Court, J. & Raven, J. (1988). Raven's standard Progressive Matrices. London.

- Reilly, J., McIntire, M. & Bellugi, U. (1990). FACES: The relationship between language and affect. *From Gesture to Language in Hearing and Deaf Children*. V. Volterra and C. J. Erting, Springer-Verlag: 128-141.
- Reilly, J. S. & McIntire, M. (1991). WHERE SHOE: The acquisition of WH-questions in ASL. *Papers and Reports in Child Language Development*. Stanford University, Department of Linguistics: 104-111.
- Reilly, J., McIntire, M. & Bellugi, U. (1992). Affective prosody in American Sign Language, *Sign Language Studies* 75: 113-128.
- Reilly, J. & Bellugi, U. (1996). Competition on the face: Motherese in ASL. *Journal of Child Language* 23: 219-239.
- Reilly, J. (2006). How faces come to serve grammar: The development of nonmanual morphology in ASL. *Advances in the sign language development of deaf children: Perspectives on deafness*. B. Schick, Marschark, M & Spencer, P.E, Oxford University Press: 262-290.
- Riberio, L. A. & Fearon, P. (2010). Theory of mind and attentional bias to facial emotional expressions: a preliminary study. *Scandinavian Journal of Psychology* 51(4): 285-9.
- Riby, D.M. & Hancock, P.J.B. (2008). Viewing it differently: Social scene perception in Williams syndrome and autism. *Neuropsychologia* 46: 2855-2860.
- Riby, D. M. & Hancock, P.J.B. (2009). Looking at movies and cartoons: Eye-tracking evidence from Williams syndrome and autism. *Journal of Intellectual Disability Research* 53(2): 169-181.
- Rinn, W. E. (1984). The neuropsychology of facial expressions: A review of the neurological and psychological mechanisms for producing facial expressions. *Psychological Bulletin* 95: 52-77.
- Ro, T., Russell, C. & Lavie, N. (2001). Changing faces: A detection advantage in the flicker paradigm. *Psychological Science* 12: 94-99.
- Ro, T., Friggel, A. & Lavie, N. (2007). Attentional biases for faces and body parts. *Visual Cognition* 15(3): 322-348.
- Roberts, C. & Hindley, P. (1999). Practitioner Review: The assessment and treatment of deaf children with psychiatric disorders. *The Journal of Child Psychology and Psychiatry and Allied Disciplines* 40: 151-167.

- Rogers, S. J., Hepburn, S.L., Stackhouse, T. & Wehner, E. (2003). Imitation performance in toddlers with autism and those with other developmental disorders. *Journal of Child Psychology and Psychiatry* 44(5): 763-781.
- Roid, G. H., Miller, L. & Wooddale, J. (1997). Leiter International Performance Scale-Revised. Illinois, Stoeling.
- Roper, L., Arnold, P. & Monteiro, B. (2003). Co occurrence of autism and deafness: diagnostic considerations. *Autism* 7(3): 151-167.
- Rosenhall, U., Nordin, V., Sandstrom, M., Ahlsen, G. & Gillberg, C. (1999). Autism and hearing loss. *Journal of Autism and Developmental Disorders* 29(5): 349-357.
- Rossion, B., Dricot, L., Devolder, A., Bodart, J.M., Crommelinck, M., De Gelder, B. Zoontjes, R. (2000). Hemispheric asymmetries for whole-based and part-based face processing in the human fusiform gyrus. *Journal of Cognitive Neuroscience* 12(5): 793-802.
- Rump, K. M., Minshew, N.J., Giovanelli, J.L. & Strauss, M.S. (2009). The development of emotion recognition in individuals with autism. *Child Development* 80(5): 1434-1447.
- Russell, P.A., Hosie, J.A., Gray, C.D., Scott, C., Hunter, N., Banks, J.S. Macaulay, M.C. (1998) The development of theory of mind in deaf children. *Journal of Child Psychol. Psychiat.* 39(6):903-910.
- Samuelson, L.K. & Smith, L.B. (2000). Children's attention to rigid and deformable shape in naming and non naming tasks. *Child Development*. 71: 1555-1570.
- Sandler, W. & Lillo-Martin, D. (2006). *Sign Language and Linguistic Universals*. Cambridge, Cambridge University Press: 431-470.
- Sandler, W. (2006). Sign language: an overview. *Encyclopedia of language and linguistics: 2nd ed*: 1-19.
- Sasson, N. (2006). The development of face processing in autism. *Journal of Autism and Developmental Disorders* 36(3): 381-394.
- Scanlan, C. B. & Johnston, L.C. (1998). Are faces "special" objects? Associative and semantic priming of face and object recognition and naming. *The Quarterly Journal of Experimental Psychology, A* 551(41): 853-882.
- Scawin, C. (2003). Communication and social interaction checklist for deaf children who sign. MSc project. London, City University.

Schembri, A. (2008). The British Sign Language Corpus Project: Open Access Archives and the Observer's Paradox. Construction and Exploitation of Sign Language Corpora Workshop. Marrackech.

Schmidt, K. L., Ambadar, Z., Cohn, J.F. & Reed, I. (2006). Movement differences between deliberate and spontaneous facial expressions: Zygomaticus major action in smiling. *Journal of Nonverbal Behaviour* 30(1): 37-52.

Schriebman, L., Kohlenberg, B.S. & Britten, K.R. (1986). Differential responding to content and intonation components of a complex auditory stimulus by nonverbal and echolalic children. *Analysis and Intervention in Developmental Disabilities* 6(1-2): 109-125.

Schultz, R. T., Gauthier, I., Klin, A., Fulbright, R., Anderson, A., Volkmar, F., Skudlarski, P., Lacadie, C., Cohen, D.J. & Gore, J.C. (2000). Abnormal ventral temporal cortical activity during face discrimination among individuals with autism and asperger syndrome. *Archives of General Psychiatry* 57: 331-340.

Schultz, R. T., Grelotti, D.J., Klin, A., Kleinman, J., Van der Gaag, C., Marois R. Skudlarski, P. (2003). The role of the fusiform face area in social cognition implications for the pathobiology of autism. *Phil. Trans. R. Soc. Lond. B*, 358: 415-427.

Schwartz, G.E., Davidson, R.J. & Maer, F. (1975). Right hemisphere lateralization for emotion in the human brain: Interactions with cognition. *Science*, 190(4211):286-288.

Sebe, N., Lew, M.S., Cohen, I., Sun, Y., Gevers, T. & Huang, T. (2004). Authentic facial expression analysis. Proceedings of international conference on automatic face and gesture recognition.

Senju, A., Southgate, V., White, S. & Frith, U. (2009). Mindblind eyes: An absence of spontaneous Theory of Mind in Asperger Syndrome. *Science* 325: 883-885.

Sevlever, M. & Gillis, J.M (2010). An examination of the state of imitation research in children with autism: Issues of definition and methodology. *Research in Developmental Disabilities*. 31(5):976-84.

Shick, B., De Villiers, P., De Villiers, J. & Hoffmeister, R. (2007). Language and theory of mind: A study of deaf children. *Child Development* 78(2): 376-396.

Shield, A. (2010). Phonological errors in the sign language of children with autism. Unpublished doctoral dissertation. University of Texas.

Slater, A. & Quinn, P.C. (2001). Face recognition in the newborn infant. *Infant and Child Development* 10: 21-24.

Smalley, S. L. & Asarnow, R.F. (1990). Brief report: Cognitive subclinical markers in autism. *Journal of Autism and Developmental Disorders* 20(2): 271-278.

Smith, I. M. & Bryson, S.E.(1994). Imitation and action in autism: A critical review. *Psychological Bulletin* 116(2): 259-273.

Smith, C.A. & Scott, H.S. (1997). A componential approach to the meaning of facial expressions. *The psychology of facial expression*. Russell, J.A & Fernandez, J. New York , Cambridge University Press, Chapter 10: 229-254.

Smith, N., Hermelin, B. & Tsimpli, I. (2003). Dissociation of social affect and theory of mind in a case of Asperger syndrome. *Working paper in Linguistics*. 15: 357-377.

Smith, N., Tsimpli, I., Morgan, G. & Woll, B. (2010). *The signs of a savant: Language against the odds*. London, Cambridge University Press: 99-140.

Snow, D. (2000). The emotional basis of linguistic and nonlinguistic intonation: Implications for hemispheric specialisation. *Developmental Neuropsychology* 17(1): 1-28.

Sodian, B. & Frith, U. (1992). Deception and sabotage in autistic, retarded and normal children. *Journal of Child Psychol. Psychiat* 33(3): 591-605.

Southgate, V., Gergely, G. & Csibra, G. (2009). Does the mirror neuron system and its impairment explain human imitation and autism? *Mirror neuron systems: the role of mirroring processes in social cognition*, Pineda, J.A, Springer, Berlin: 331-354

Steele, H., Steele, M., Croft, C. & Fonagy, P. (1999). Infant-Mother attachment at one year predicts children's understanding of mixed emotions at six years. *Social Development*, 8(2):161-178.

Steffenburg, S. (1991). Neuropsychiatric assessment of children with autism: A population based study. *Developmental Medicine and Child Neurology* 33: 495-511.

Stewart, D.A. (2006) *Barron's American Sign Language: The easy way*, Barron's Educational Series. New York.

Stoddart, K. P., McColl, C., Lowe, C. & Temple, V. (2003). Hearing impairment in adults with pervasive developmental disorders. *Journal of Developmental Disabilities* 10(1): 123-128.

Stone, W. L., Ousley, O.Y. & Littleford, C.F. (1997). Motor imitation in young children with autism: What's the object? *Journal of Abnormal Child Psychology* 25(6): 475-485.

Sutton Spence, R. & Woll, B. (1999). *The linguistics of British Sign Language: An introduction*, Cambridge University Press: 65-99.

- Swettenham, J., Charman, T., Baron-Cohen, S., Baird, G., Cox A., Drew, A et al., (1998). The frequency and distribution of spontaneous attention shifts between social and non social stimuli in autistic, typically developing and non autistic developmentally delayed infants. *Journal of Child Psychology and Psychiatry* 39(5): 747-753.
- Szymanski, C. & Brice, P.J. (2008). When autism and deafness co exist in children: what we know now. *Odyssey: Directions in Deaf Education*. 9: 10-15.
- Tager Flusberg, H. (1981b). On the nature of linguistic functioning in early infantile autism. *Journal of Autism and Developmental Disorders* 11: 45-46.
- Tager Flusberg, H. (1989). An analysis of discourse ability and internal state lexicons in a longitudinal study of autistic children. Paper presented at the Biennial Meeting of the Society for Research in Child Development, Kansas City.
- Tager Flusberg, H. & Sullivan, K. (1994). A second look at second order belief attribution in autism. *Journal of Autism and Developmental Disorders* 24(5): 577-586.
- Tager Flusberg, H. (2003). Exploring the relationship between theory of mind and social-communicative functioning in children with autism. *Individual differences in theory of mind: Implications for typical and atypical development*. B. Repacholi and V. Slaughter. Hove, UK, Psychology press: 197-212.
- Tamar Jackson, R., Orton, R. & Un, P. (1997). A comparison of non manual signals among hearing, hard of hearing and deaf signers. Unpublished.
- Tardif, C., Laine, F., Rodriguez, M. & Gepner, B. (2007). Slowing down presentation of facial movements and vocal sounds enhances facial expression recognition and induces facial vocal imitation in children with autism. *Journal of Autism and Developmental Disorders* 37: 1469-1484.
- Tcherkassof, A., Bollon, T., Dubois, M., Pansu, P. & Adam, J.M. (2007). Facial expressions of emotions: A methodological contribution to the study of spontaneous and dynamic emotion faces. *European Journal of Social Psychology* 37: 1325-1345.
- Thomas, L. A., De Bellis, M.D., Graham, R. & LaBar, K.S. (2007). Development of emotional facial recognition in late childhood and adolescence. *Developmental Science* 10: 547-558.
- Toichi, M. & Kamio, Y. (2001). Verbal association for simple common words in high functioning autism. *Journal of Autism and Developmental Disorders* 31(5): 483-490.
- Tomblin, B. (2009). Is there an excess of SLI in the autism population. London, City University.

- Traxler, C. B. (2000). The Stanford Achievement Test, 9th edition: National norming and performance standards for deaf and hard-of-hearing students. *Journal of Deaf Studies and Deaf Education* 5: 337-348.
- Tyrone, M. E. (2005). An Investigation of Sign Dysarthria. Unpublished doctoral dissertation, London, City University.
- Valli, C. & Lucas, C. (2000). *Linguistics of American Sign Language: An introduction*. Washington DC, Clerc Books: 121-139.
- Valstar, M. F., Pantic, M., Ambadar, Z. & Cohn, J.F. (2006). Spontaneous vs. posed facial behaviour: Automatic analysis of brow actions. *ICMI*: 162-170.
- Veinburg, S. & Wilbur, R. (1990). A linguistic analysis of the negative headshake in American Sign Language, *Sign Language Studies* 68: 217-244.
- Vicari, S., Reilly, J., Pasqualleti, P., Vizzotto, A. & Caltagirone, C. (2000). Recognition of facial expressions of emotions in school-age children: the intersection of perceptual and semantic categories. *Acta Paediatrica* 89(7): 836-845.
- Vinson, D. P., Cormier, K., Denmark, T., Schembri, A. & Vigliocco, G. (2008). The British Sign Language Norms for age of acquisition, familiarity and iconicity. *Behavior Research Methods* 40(4): 1079-1087.
- Volker, M., Lopata, A.C., Smith, D.A. & Thomeer, M.L. (2009). Facial encoding of children with high functioning autism spectrum disorders. *Focus on Autism and Other Developmental Disabilities* 24(4): 195-204.
- Volkmar, F., Klin, A., Schultz, R., Rubin, E. & Bronen, R. (2000). Asperger's Disorder: Clinical case conference. *American Journal of Psychiatry* 157: 262-267.
- Wallace, S., Coleman, M. & Bailey, A. (2008). Face and object processing in autism spectrum disorders. *Autism Research* 1(1): 43-51.
- Wang, A.T., Lee, S.S., Sigman, M. & Dapretto, M. (2007). Reading affect in the face and voice. *Arch. Gen. Psychiatry* 64: 698-708.
- Webster, C., McPherson, D.H., Sloman, L., Evans, M.A. & Kuchar, E. (1973). Communicating with an autistic boy by gestures. *Journal of Autism and Childhood Schizophrenia* 3: 337-346.
- Weichbold, V. & Herka, H. (2003). Performance of hearing impaired children on Raven's coloured progressive matrices test. *International Journal of Pediatric Otorhinolaryngology* 67(11): 1213-1217.

- Wells, B. & Peppe, S. (2003). Intonation abilities of children with speech and language impairment. *Journal of Speech, Language and Hearing Research* 46: 5-20.
- Wells, B., Peppe, S. & Goulondris, A. (2004). Intonation development from five to thirteen. *Journal of Child Language* 31: 749-778.
- Werner, E., Dawson, G., Osterling, J. & Dinno, N. (2000). Brief report: Recognition of autism spectrum disorder before one year of age: a retrospective study based on home videos. *Journal of Autism and Developmental Disorders* 30(2): 157-162.
- White, S., Hill, E., Winston, J. & Frith, U. (2006). An islet of social ability in Asperger syndrome: Judging social attributes from faces. *Brain and Cognition* 61: 69-77.
- WHO (1992). ICD-10: The ICD-10 Classification of mental and behavioural disorders: clinical descriptions and diagnostic guidelines. Geneva, World Health Organisation.
- Widen, S. C. & Russell, J.A. (2003). A closer look at pre-schoolers freely produced labels for facial expressions. *Developmental Psychology* 39: 114-128.
- Widen, S.C. & Russell, J.A. (2004). The relative power of an emotion's facial expression, label and behavioural consequence to evoke preschoolers' knowledge of its cause. *Cognitive Development*, 19: 111-125.
- Wilbur, R. (1991). *Intonation and focus in American Sign Language*. ESCOL'90: Proceedings of the seventh eastern states conference on linguistics
- Wilbur, R. & Ronnie, B (1994). Eyeblinks and ASL phrase structure. *Sign Language Studies* 23(84): 221 240.
- Williams, J. H., Whiten, J.A. & Singh, T. (2001). Imitation mirror neurons and autism. *Neuroscience and Biobehavioural Reviews* 25: 287-295.
- Williams, J. H. G., Waiter, G.D., Gilchrist, A., Perrett, D., Murray, A.D. & Whiten, J.A. (2006). Neural mechanisms of imitation and mirror neuron functioning in autistic spectrum disorder. *Neuropsychologia* 44: 610-621.
- Wimmer, H.M. & Perner, J.A. (1983). Beliefs about beliefs. Representation and constraining function of wrong beliefs in young children's understanding of deception. *Cognition* 13: 41-68.
- Wing, L., Leekam, S.R., Libby, S.J., Gould, J. & Larcombe, M. (2002). The Diagnostic Interview for Social and Communication Disorders: background, inter-rater reliability and clinical use. *Journal of Child Psychology and Psychiatry* 43(3): 307-325.
- Witelson, S.F. & Pallie, W. (1973). Left hemisphere specialization for language in the newborn: Neuroanatomical evidence of asymmetry. *Brain* 96:641-646.

Woll, B. (1998). Development of signed and spoken languages. *Issues in deaf education*. S. Gregory, P. Knight, W. McCracken, S. Powers and S. Watson, David Fulton publishers: 58-68.

Woll, B. & Rentelis, R (2009). Facial expression use in deaf-blind signers. London, UCL.

Woolfe, T., Want, S.C. & Siegal, M. (2002). Signposts to development: Theory of mind in deaf children. *Child Development* 73(3): 768-778.

Yirmiya, N., Kasari, C., Sigman, M. & Mundy, P. (1989). Facial expressions of affect in autistic mentally retarded and normal children. *Journal of Child Psychol. Psychiat* 30(5): 725-735.

Yirmiya, N., Sigman, M., Kasari, C. & Mundy, P. (1992). Empathy and cognition in high functioning children with autism. *Child Development* 63: 150-160.

Yue, X., Bosco, S.T. & Biederman, I. (2006). What makes faces special? *Vision Research* 46: 3802-3811.

Zeng, Z., Fu, Y., Roisman, G.I., Wen, Z., Hu, Y. & Huang, T. (2006). Spontaneous emotional facial expression detection. *Journal of Multimedia* 1: 1-8.

Zeshan, U. (2004). Hand, head and face: Negative constructions in sign languages. *Linguistic Typology* 8: 1-57.

Ziatas, K., Durkin, K. & Pratt, C. (1998). Belief term development in children with autism, Asperger syndrome, specific language impairment and normal development: Links to theory of mind development. *Journal of Child Psychol. Psychiat* 39: 755-763.

Zimmerman, A. W. (2005). The immune system. *The neurobiology of autism*. M. Bauman and T. L. Kemper. Baltimore, The John Hopkins University Press: 371-386.

Table of abbreviations

Abbreviations used in this thesis and their meanings are provided in the table below

Symbol	Meaning
ASD	Autism Spectrum Disorder
BSL	British Sign Language
ToM	Theory of Mind
DSM IV	Diagnostic and Statistical Manual for Mental Disorders
ICD 10	International Classification of Disease
APA	American Psychological Association
ADOS-G	Autism Diagnostic Observation Schedule- Generic
DCYPFS	Deaf Child and Young Person Family Service
SRS	Social Responsiveness Scale
RNID	Royal National Institute for the Deaf
UNHSP	Universal Newborn Hearing Screening Programme
NHS	National Health Service
MNS	Mirror Neuron System
EEG	Electroencephalography
NMMs	Non-Manual Markers
ASL	American Sign Language
AAC	Augmentative and Alternative Communication Therapies
CCC	Children's Communication Checklist
LPP-2	Language Proficiency Profile
fMRI	Functional Magnetic Resonance Imaging
NDCAMHS	National Deaf Child and Adolescent Mental Health Service
RSPM	Ravens Standard Progressive Matrices
DISCO	Diagnostic Interview for Social and Communication Disorders
NRES	National Research Ethics Service
UCL	University College London
DCAL	Deafness Cognition and Language Research Centre
BSLNST	British Sign Language Narrative Skills Test
BSLRST	British Sign Language Receptive Skills Test
BFRT	Benton Facial Recognition Test
SD	Standard Deviation
HFA	High Functioning Autism
LFA	Low Functioning Autism
ESCS	Early Social Communication Scales
ELAN	Eudico Linguistic Annotator

LH	Left Hemisphere
RH	Right Hemisphere
LD	Learning Disabled
LHD	Left Hemisphere Damage
RHD	Right Hemisphere Damage
ASLSRT	American Sign Language Sentence Repetition Test
NIVs	Negative Incorporated Verbs
CDI	Children's Developmental Inventory
MS	Milliseconds
ANOVA	Analysis of Variance
Q1 (in boxplot key)	First Quartile
Q3 (in boxplot key)	Third Quartile
Min (in boxplot key)	Minimum
Max (in boxplot key)	Maximum
FACS	Facial Action Coding System
AU	Action Units
NGT	Sign Language of the Netherlands